POWER PLANT ENGINEERING

Established Over 30 Years

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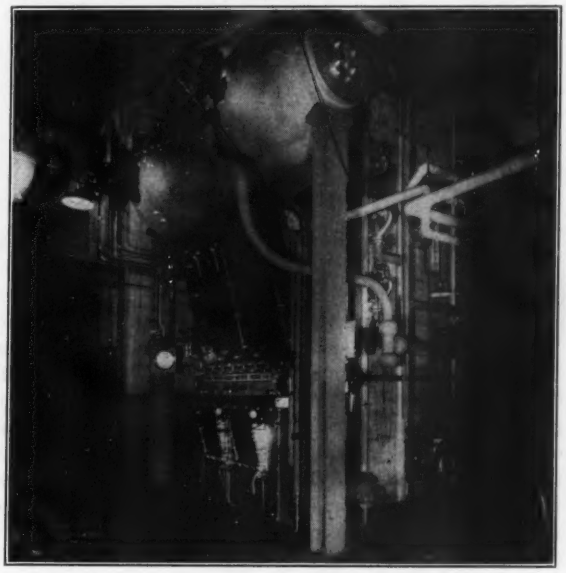


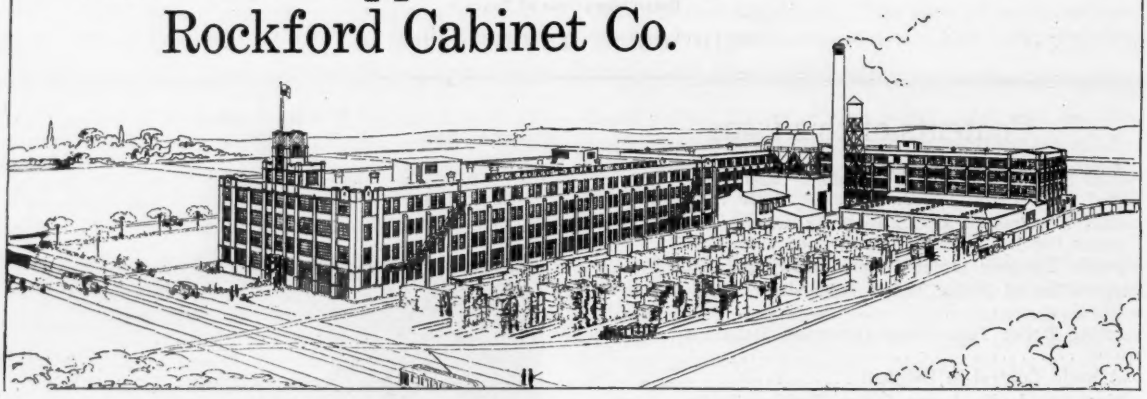
Found—Twenty Per Cent

NOT THAT it was lost exactly, for engineers have known for a good many years just where it has been, but they were afraid to go after it. During these years, many millions of tons of coal have been burned in power plants that from now on will be saved. This solution to our lost millions has not come all of a sudden, as did Archimedes' solution to the proportion of gold and silver in the King's crown when the latter took his daily (or perhaps it was his semi-annual) bath in an overfull tub. The solution started when the thermodynamics of steam was first investigated.

Recently, however, a veritable gold mine has been opened up, so recently, in fact, that we are still eyeing askance the work of those who had the temerity to put into operation a steam plant developing and using steam at 1200 lb. pressure. Now that somebody has blazed the trail, many will follow to beat down the briers, build the bridges and mine the gold.

So we find that safe standards are being developed for us to follow. Piping is among the first equipment to be subjected to study and you will find the principal points under consideration discussed on page 950 of this issue. In the illustration above is a boiler built especially for testing and improving Consolidated safety valves but it will also serve to try out other boiler and piping accessories which are proposed for use with steam at 1200 lb.

Sawdust Supplies Steam for Rockford Cabinet Co.



WOOD WASTE BURNED IN NEW MODERN POWER PLANT GIVES HIGH BOILER RATINGS AND MAKES COMPANY NEARLY INDEPENDENT OF OUTSIDE FUEL

ECONOMY IS A DOMINANT factor in industry and, although the cost of power may or may not be large when considered as a percentage of the total expense, few industries can consider this item alone and not feel that it warrants serious consideration. In the wood-working industry the problem is doubly important because the power plant is expected effectively to solve the question of sawdust and shaving disposal as well as produce power. The action of the Rockford Cabinet Co., Rockford, Ill., may be considered as typical of the consideration being given to the power question by smaller industrial establishments.

Following changes from line shaft to individual motor drive on all machines, this company made plans to replace the old power plant with one of modern design capable of meeting the entire power load. The old plant had outlived its economic life, while the electric load had increased far beyond the generating capacity of the station, making the purchase of central station power necessary.

Due to space limitations and the necessity for keeping the old boilers in operation during construction, the problem was considerably complicated, a fact which is not apparent in the finished plant and reflects the care and attention with which the engineers handled the design. In the old plant the boilers were located where the uniflow engine now stands and were kept in operation until the new boilers were cut in service. Purchased power was used exclusively during this time; the

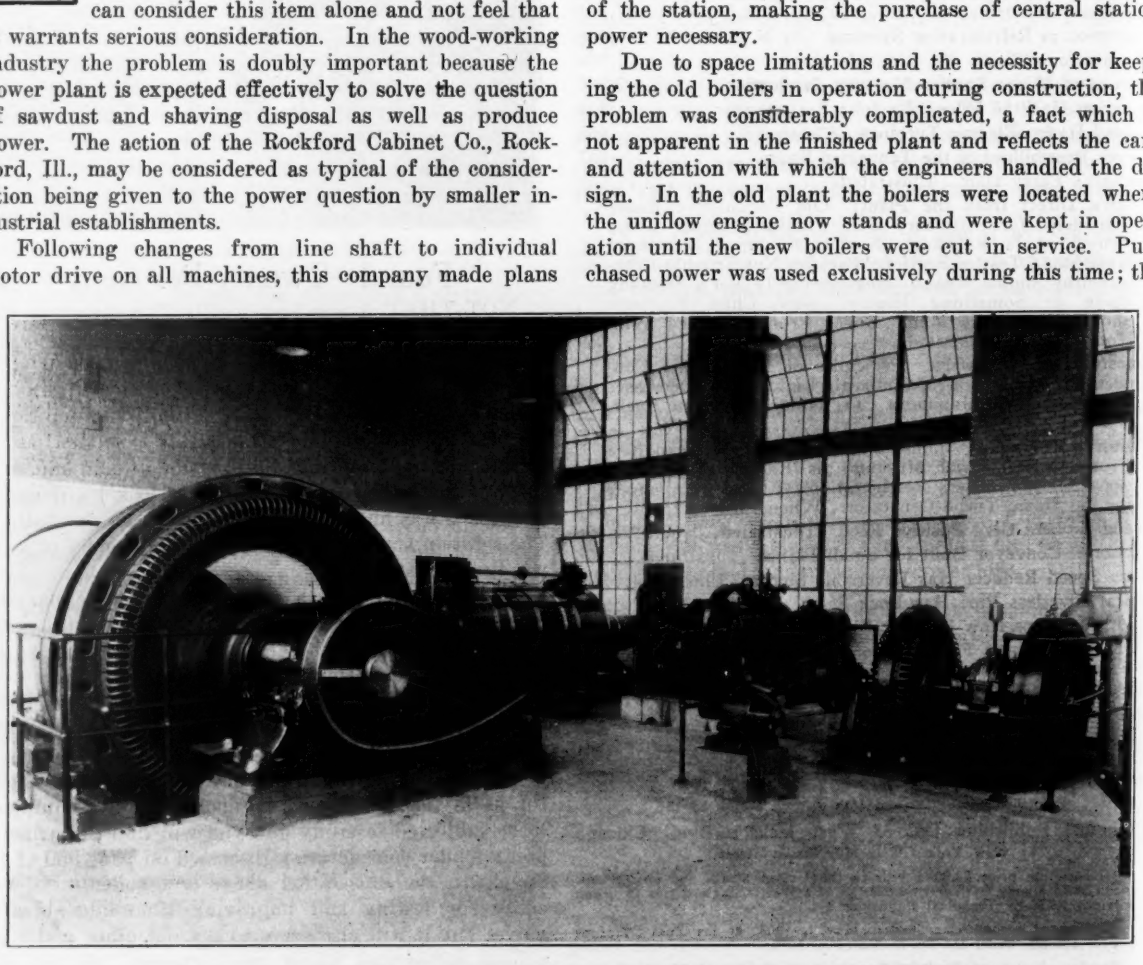


FIG. 1. THE ENGINE ROOM IS WELL LIGHTED WITH SPACE ALLOWED FOR FUTURE UNITS

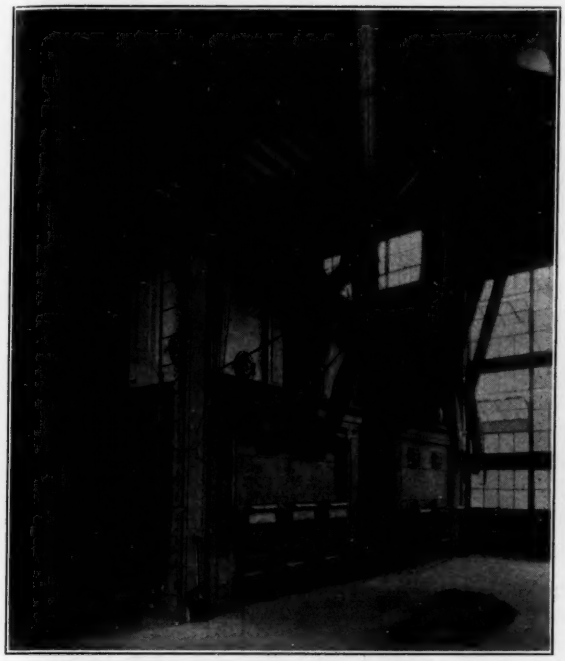


FIG. 2. SAWDUST IS FED TO THE BOILERS FROM ABOVE BY GRAVITY AND COAL IS FIRED BY HAND

FIG. 3. AUXILIARIES ARE COMPACTLY ARRANGED ALONG ONE SIDE OF THE BOILER ROOM

temporary leads from three 100-kv.a. transformers can be seen coming through the window at the left of the new switchboard.

Sawdust is Collected by Blow Pipe System

In addition to power, low-pressure steam is furnished for general heating, varnish kilns and dry kilns throughout the plant. Sawdust and wood scrap from the several shops are used for fuel under the boilers and their collection, preparation, transportation and storage require an extensive mechanical system. It is expected that when the changes have been entirely completed the sawdust will carry the entire load, so that power will virtually be a by-product. At the present time about 3 t. of coal are burned a day as sawdust storage facilities are not complete and coal is almost entirely depended upon through the night and over holidays when the shops are not working.

Storage and Reclaiming Equipment is Important Feature

Sawdust and shavings are collected in the various buildings and blown to the power house by three single and three double fans with a total of 335 motor horsepower. Larger pieces of scrap and blocks are hogged, reduced to splinters ranging from sawdust to pieces the

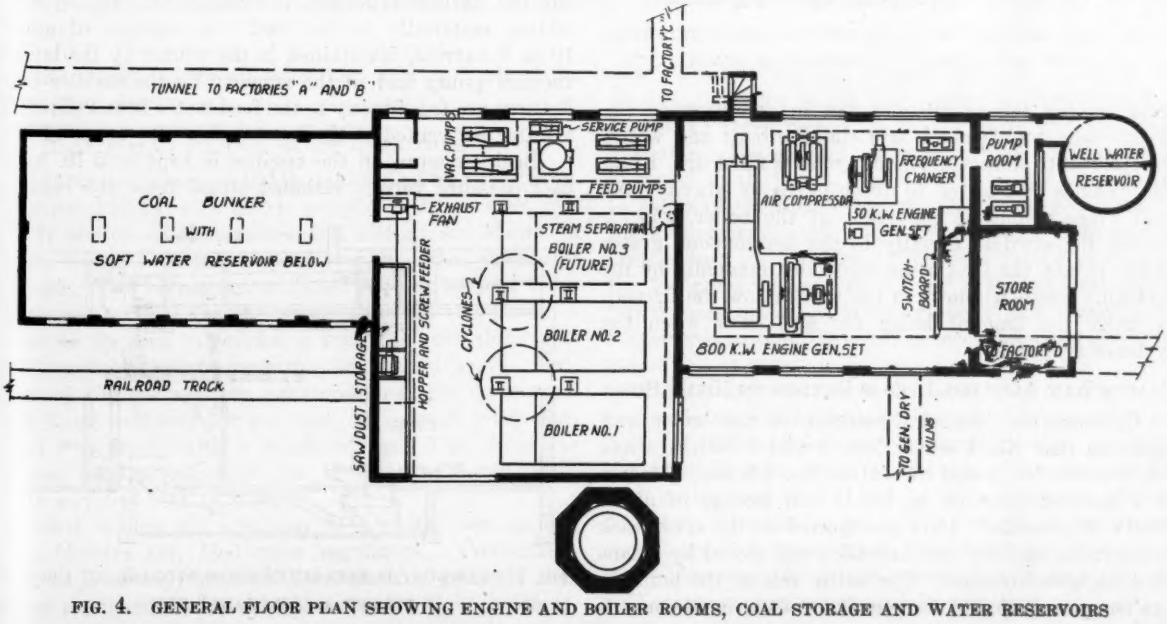


FIG. 4. GENERAL FLOOR PLAN SHOWING ENGINE AND BOILER ROOMS, COAL STORAGE AND WATER RESERVOIRS

size of an ordinary rubber eraser. At the power house the sawdust is collected in two cyclones where the air is separated and sawdust, beyond the immediate requirements of the boilers, is automatically delivered by gravity to the storage compartment in front of the boilers. Instead of leaving the stored fuel to be fired by hand as needed, a screw feeder and blower have been provided to reclaim and elevate the fuel to the cyclones. This arrangement, as shown in Fig. 7, has a material effect on maintaining constant furnace conditions by eliminating the usual interruption of hand firing. The bottom of the storage bin forms a small hopper and the stored material is fed into the suction of an exhaust fan by a screw feeder operating at a constant speed of 16 r.p.m. The fan then picks up the sawdust and elevates it to the cyclones to be fed to the furnace in the regular manner.

Firemen have instant control of the reclaiming equipment and must keep close track of the flow of fuel into the cyclones from the shops. No damage can result

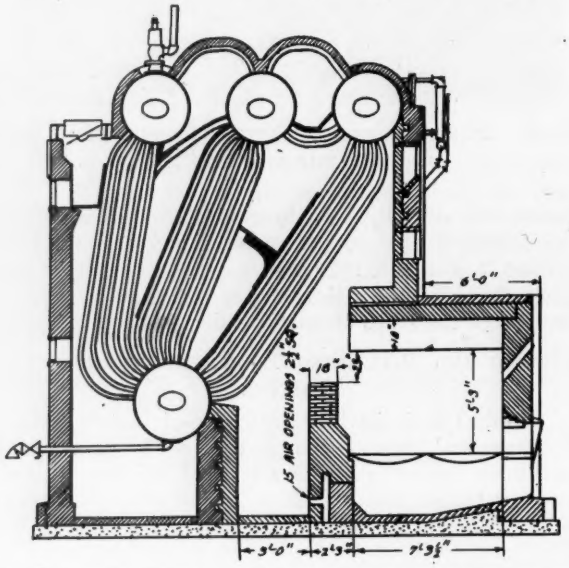


FIG. 5. CROSS-SECTION OF BOILER SETTING AND DUTCH OVEN WITH DETAILS OF THE COMBUSTION SPACE

from leaving the feeder and fan in operation as the wood waste would travel in a closed circuit and would be returned to storage after the cyclones filled up. From the cyclones fuel is fed to dutch ovens by gravity; the feed pipes visible at the front of the boiler, Fig. 2, deliver the sawdust directly to the herringbone grates at two points, the feed being controlled manually by the fireman. Small windows in the pipes allow the fireman to judge the amount being fed and show when the cyclones are empty.

Practically All Coal Used is Burned on Night Shift

Cyclones are located directly over the boiler and piped so that No. 1 serves Nos. 1 and 2 boilers, while No. 2 serves No. 2 and the future No. 3 boiler. In case of a sawdust shortage an inside coal storage of about 1250 t. is provided. Cars are spotted on the spur track just outside and the coal unloaded and stored by means of a portable unloader. The entire side of the building can be opened up and the conveyor swung inside or out-

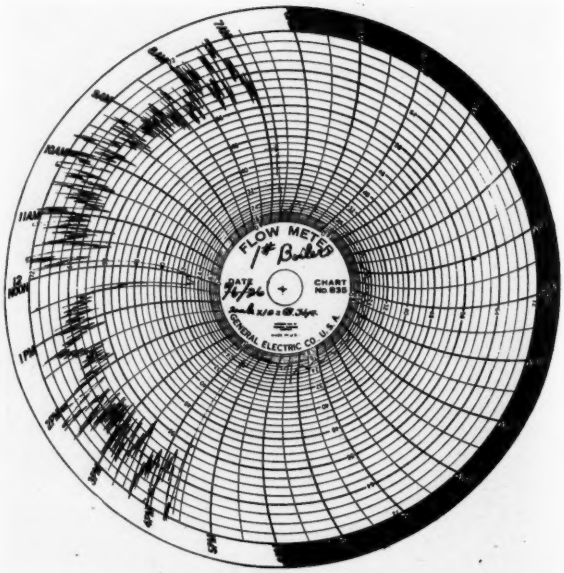


FIG. 6. A TYPICAL STEAM FLOW CHART SHOWING THE CONSISTENT HIGH RATING AT WHICH THE BOILERS ARE OPERATED DURING THE DAY

side by means of a small hand hoist. Because of the small quantity of coal used, no further provision has been made for conveyors but it is taken to the adjoining boiler room in wheelbarrows and fired by hand. Several weeks' operation shows an average consumption of about 3 t. during a normal working day and about twice this amount over Sundays and holidays when no sawdust is available from the shops.

From 7 a.m. to 4:30 p.m. the load carried averages about 640 b.hp. but at 4:30 drops to around 200 b.hp. for the night. This night load is made up entirely of dry kilns with an equivalent direct radiating surface of from 35,000 to 40,000 sq. ft., a continuous load 24 hr. a day throughout the year. During the winter a total heating surface of approximately 128,000 sq. ft. throughout the various buildings is connected to the system, adding materially to the load. A vacuum of about 10 in. is carried, maintained in the winter by the larger vacuum pump and in the summer by the smaller one. Returns are fed directly to the feed-water heater through a water leg vented at the top to allow the escape of air.

Back pressure on the engines is kept at 5 lb. by a back-pressure valve. Exhaust steam from the engines

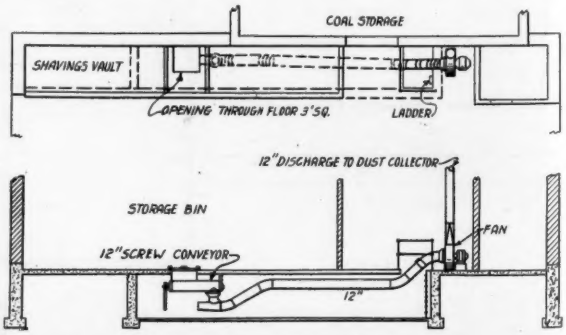


FIG. 7. SAWDUST IS RECLAIMED FROM STORAGE BY A SCREW FEEDER AND EXHAUST FAN

and pumps is usually sufficient to supply the low-pressure system, but to take care of high peaks and emergencies the high-pressure system is cross connected through two reducing valves in series, reducing the pressure from 100 to 35 and from 35 to 5 lb., respectively. Exhaust steam passes through an external oil separator to the feed-water heater and the second oil separator. Steam required to heat the feed water is automatically drawn into the heater shell while the remainder passes to the low-pressure heating system or the atmosphere with the collection system completed, the supply of sawdust is found to be insufficient to carry the entire load.

Rain water, collected from roofs of the plant and stored in a 350,000 gal. reservoir located under the coal storage, is used for feed water. It is delivered to the feed-water heater by a small float controlled service pump, as make up requirements demand. The heater is of the open induction type, rated at 3000 hp. and set well above the boiler feed pumps so that water of 200

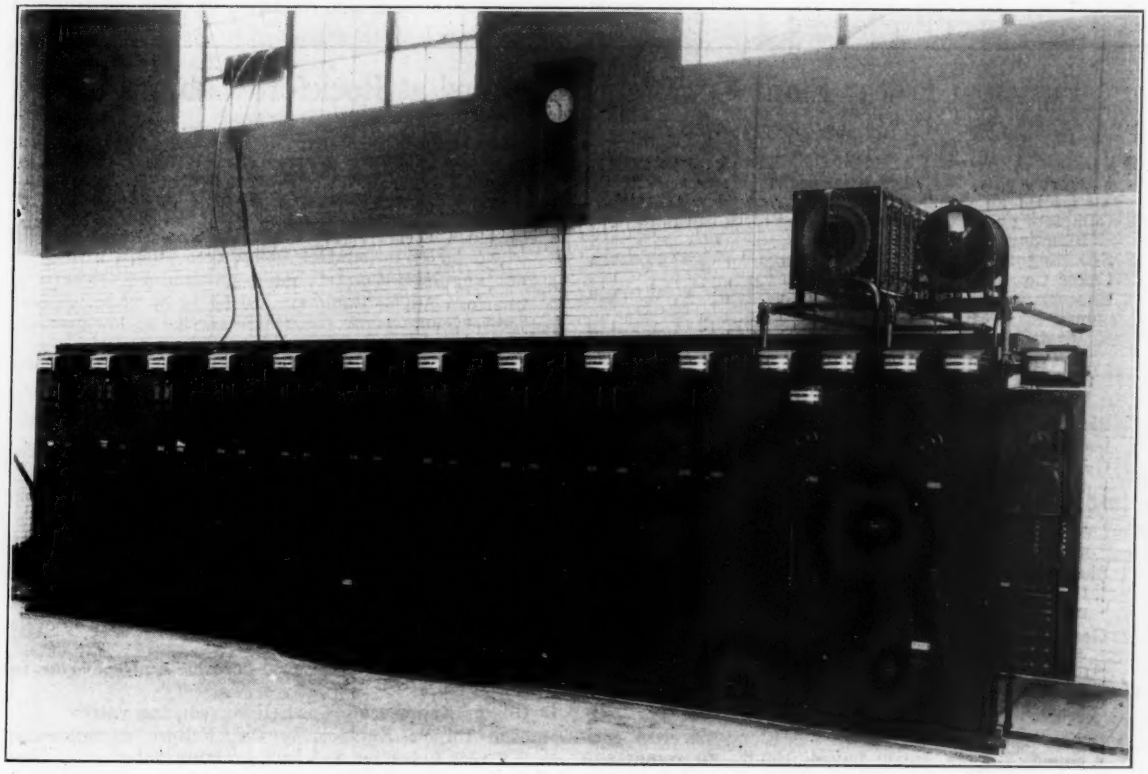


FIG. 8. A BLACK SLATE SWITCHBOARD OF GENEROUS PROPORTIONS TAKES CARE OF THE ENTIRE PLANT

as the balance of the electrical and heating loads at the time may determine.

High Boiler Ratings Maintained During Day

Saturated steam at 150 lb. is supplied by two 352-hp. Stirling boilers with dutch ovens. A front view and cross section of the boilers and setting are shown in Figs. 2 and 5, with many of the important details of design. Two boilers are installed with space and foundations provided for the third, although the performance of the two in service is such that the third unit will probably not be required for several years. Ratings of 200 per cent are not uncommon, the daily average being well over 180 per cent. The dutch oven measures 9 by 8 ft. with a height of over 5 ft. from the grates to the bottom of the 18-in. spring arch, built with a radius of 7 ft. 6 in.

Both boilers are equipped with steam flow meters, soot blowers and feed-water regulators. Combustion control is entirely manual, although it is probable that some provision for automatic control will be made if, deg. F. can be handled without difficulty. Each of the duplicate simplex boiler feed pumps is large enough to handle all three boilers, so that a spare will always be available. Piping and arrangement of the auxiliaries is shown in the plans, Fig. 4. This is the only piping in the plan installed above the floor, the remainder being located in tunnels under the floor and indicated by dotted lines on the plan. The main tunnel containing the low-pressure headers is 8 by 8 ft. but branches to the various buildings are correspondingly smaller; the longer ones are simply trenches accessible from above for inspection or repair.

High-pressure steam is delivered to a header in the engine room after passing through a separator. Because of the low head room, a standard steam separator could not be used, and a special design for this particular location was worked out by the engineers and built to order. The header extends the length of the engine room, serves the three units there, and goes through to the pump room to furnish steam for driving the two well water pumps which will be installed.

Safety Features Are Important

Excellent lighting effects and the neat, compact arrangement of the engine room, with its white tile walls, are well brought out in Fig. 1. The three steam units are arranged without crowding to allow considerable space in one corner of the building for future units which expansion may require. Safety requirements have not been overlooked, pits and revolving parts which might prove dangerous being well protected by substantial railings.

Current is generated at 440 v., 3 phase, 60 cycles, by two units: the larger, an 800-kw., 80 per cent power factor generator, direct connected to a 32 by 36-in., 150-r.p.m. Unaflow engine is used throughout the day while the smaller, a 50-kw., 80 per cent power factor generator, direct connected to a 10 by 12-in., 300-r.p.m. counterflow engine is used to carry the night load. The exciter for the large unit is driven from the main shaft by a silent chain drive at 725 r.p.m., while the small generator exciter is belted, and operates at 1150 r.p.m. Complete switchboard facilities are provided by 12 black slate panels, with instruments and voltage regulator. No fuses are used as all circuits are protected by circuit breakers which are rapidly coming into popularity in spite of a somewhat higher initial investment. Interrupted circuits can be put in service again much quicker than a fuse could be replaced, the breaker may be reset quickly to meet changed conditions, while the rugged construction greatly decreases maintenance expense.

Many motors used on woodworking machines operate at unusually high speeds and a 25-kw. frequency changer set supplies current at 120 cycles for this high-speed service. A cross compound, steam-driven air compressor with air cylinders 7½ and 12 by 12 in. supplies air at 100 lb. to two 30-in. by 5-ft. air receivers for general service throughout the shops.

When all details are completed, the factory will be entirely self contained and the plant will furnish all the power and steam required, as well as pump the water, with fuel produced in the shops. A 6-in. well is being drilled to an estimated depth of 1000 ft. to supply drinking and process water used in the plant, and in an emergency, feed water to the boilers. Pumps for well service have not yet been selected, although they will probably consist of an air lift, delivering the water to a surface tank from which it will be elevated to an overhead pressure tank by two steam-driven service pumps similar to the one supplying make up water to the feed-water heater.

We are indebted to Peterson & Johnson, architects, for the photographs and plan drawing, particularly to E. H. Burg, their mechanical engineer, who had charge of the design and made arrangements for the inspection of the plant.

Principal Power Plant Equipment Installed at Rockford Cabinet Co.

Boilers

2 Babcock & Wilcox Co., 352-b.hp. Stirling boilers with Dutch ovens, for burning sawdust. Saturated steam supplied at 150 lb.
2 Complete boiler units of Diamond Power Specialty Co., Diamond soot blowers
2 S-C. Regulator Co., S-C. boiler feed-water regulators.
2 Crane Co. safety valves
2 Babcock & Wilcox Co. blowoff valves with A. W. Cadman Mfg. Co., Gato cocks
2 General Electric Co., Type F., mechanical steam flow meters

Steam and Electrical Equipment

1 Skinner Engine Co., 32 by 36-in. Universal Unaflow engine running at 150 r.p.m. direct connected to
1 General Electric Co., 800-kw., 80 per cent power factor, 480-v., 3-phase, 60-cycle current and excited by
1 General Electric Co., 30-kw., Form 2, compound-wound, 240-v., d.c. exciter, driven at 725 r.p.m. by silent chain drive from the main shaft
1 Skinner Engine Co., 10 by 12, Steam-Tight-Valve counterflow engine, running at 300 r.p.m. and direct connected to
1 General Electric Co., 50-kw., 80 per cent power factor 480-v., 3-phase, 60-cycle generator, excited by
1 General Electric Co., 5-kw., 125-v., d.c., compound-wound exciter, driven by belt drive from the generator shaft
1 Ingersoll-Rand Co., 8/13 by 7½/12 by 12, cross compound, 2-stage, steam-driven, 100-lb. air compressor
1 General Electric Co., 25-kw., frequency changer set, operating at 1200 r.p.m. on 60-cycle current and supplying 120-cycle current for wood working machine motors
1 Marquette Elec. Switchboard Co., 12-panel, black slate switchboard, complete with General Electric Co. instruments and equipment, and
1 General Electric Co., Type 125, Form F2 voltage regulator

Pumps and Heater

1 Milwaukee Reliance Boiler Wks., 3000-hp., Reliance induction type, open feed-water heater
1 American Steam Pump Co., 6 by 6 by 10-in. simplex service pump for make-up water
2 American Steam Pump Co., outside center packed, 12 by 7 by 12-in. simplex boiler feed pumps with
2 S-C. Regulator Co. S-C. pump governors
1 American Steam Pump Co., 10 by 14 by 20-in. simplex wet vacuum pump for winter service on low-pressure system and
1 American Steam Pump Co., 6 by 8 by 12-in. simplex wet vacuum pump for summer service

Miscellaneous

1 Link-Belt Co., 12-in. screw feeder for reclaiming sawdust from the storage hopper. Driven at 16 r.p.m. by
1 Crocker Wheeler Co., 2-hp., 220-v., 3-phase, 60-cycle, 1150 r.p.m. induction motor through
1 D. O. James Mfg. Co. gear, reducing the speed from 1150 to 16 r.p.m.
1 B. F. Sturtevant Co., size 35 fan for delivering sawdust to the cyclones direct connected to
1 General Electric Co., 7½-hp., 220-v., 3-phase, 60-cycle, 1160-r.p.m. induction motor
1 Chicago Conveyor Mfg. Co., portable coal conveyor for coal storage
2 Illinois Engineering Co. Eclipse reducing valves
1 each Illinois Engineering Co., Eclipse oil separator, grease extractor and back-pressure valve
Traps supplied by Fisher Governor Co.
Piping installed by American Heating and Supply Co., and Swords Bros. of Rockford with Crane Co. pipe and fittings used throughout.
Blow pipe and sawdust storage and reclaiming system designed and installed by Central Blow Pipe Co., Chicago, Ill.
Design of plant and building by Peterson & Johnson, Rockford, Ill.

Unusual Features of Combustion Chemistry

Hydrogen in the Fuel Explains the Variation of $CO_2 + O_2$ in Flue Gas With Changes in Excess Air.

By R. T. Haslam and J. T. McCoy*

IN ANALYZING flue gases in cases where there was complete combustion (that is, no trace of CO), many have been puzzled by the fact that as the CO_2 decreased and the O_2 increased, there is an increase in the sum of these two gases.

This is due to the fact that most fuels contain "net" hydrogen which burns with some of the oxygen from the air to water which is not shown by ordinary gas analysis methods, the composition of the gases always being reported on a "dry" basis.

Net or available hydrogen is the amount of hydrogen over that sufficient to combine with the oxygen contained in the fuel. One pound of hydrogen combines with 8 lb. of oxygen. Thus in a typical bituminous coal with 5.94 per cent hydrogen and 5.12 per cent oxygen (ash- and moisture-free basis, see Table I), the net hydrogen is

$$5.94 \text{ per cent} - \frac{5.12 \text{ per cent}}{8} = 5.30 \text{ per cent.}$$

When H_2O is formed by combustion of the hydrogen of the fuel, the oxygen is said to "disappear" (that is, it does not appear in the gas analysis). The total apparent oxygen content of the flue gas ($CO_2 + O_2$) is then less than 21 per cent oxygen content of the air.

Calculation of oxygen "disappearance" is a simple matter involving only the analyses of the fuel and the flue gas. In the case of fuels containing negligible quantities of nitrogen, such as coke, coal, fuel oil, and some gases, it is possible to calculate oxygen "disappearance" directly from a flue gas analysis alone.

TABLE I. THIS SHOWS REPRESENTATIVE ULTIMATE ANALYSES OF THE LEADING CLASSES OF FUELS

Fuel	Weight Percent				
	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur
Anthracite	94.01	2.68	1.74	0.99	0.62
Bituminous Coal	87.10	5.94	5.12	1.37	1.06
Fuel Oil	84.2	13.1		2.7	
Natural Gas	76.2	21.0		0.8	

TABLE II. WITH COMPLETE COMBUSTION, THESE TYPES OF FUELS WILL SHOW THESE ANALYSES WITH GIVEN AMOUNTS OF EXCESS AIR

Fuel	Flue Gas	Percent Excess Air				
		0%	50%	100%	200%	400%
Anthracite	CO_2	19.8	13.1	9.8	6.5	3.9
	O_2	0.0	7.0	10.6	14.1	16.9
	Total	19.8	20.1	20.4	20.6	20.8
Bituminous Coal	CO_2	18.4	12.1	9.0	6.0	3.6
	O_2	0.0	7.2	10.7	14.1	16.9
	Total	18.4	19.3	19.7	20.1	20.5
Fuel Oil	CO_2	15.3	10.0	7.4	4.9	2.9
	O_2	0.0	7.5	10.8	14.3	17.0
	Total	15.3	17.5	18.2	19.2	19.9
Natural Gas	CO_2	12.9	8.3	6.1	4.0	2.4
	O_2	0.0	7.5	11.0	14.5	17.1
	Total	12.9	15.8	17.1	18.5	19.5

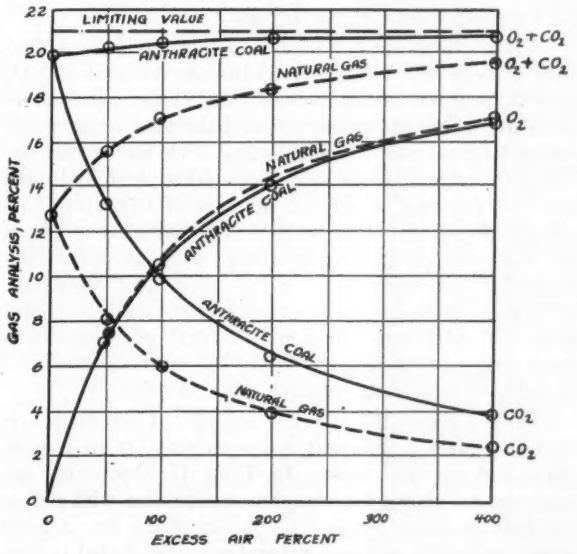


FIG. 1. THESE CURVES CONTRAST THE THEORETICAL GAS ANALYSES OF ANTHRACITE AND NATURAL GAS WHEN THERE IS COMPLETE COMBUSTION WITH VARYING PERCENTAGES OF EXCESS AIR

Consider a flue gas from burning fuel oil, analyzing 7.4 per cent CO_2, 10.8 per cent O_2, and 81.8 per cent N_2. All of the oxygen came in with the nitrogen of the air (21 per cent O_2, 79 per cent N_2) neglecting the small amount of oxygen in the fuel. This oxygen shows up in the CO_2 and O_2 found by the Orsat apparatus, and also in the H_2O which is not determined. Since the amount of nitrogen in the flue gas is known, the oxygen cor-

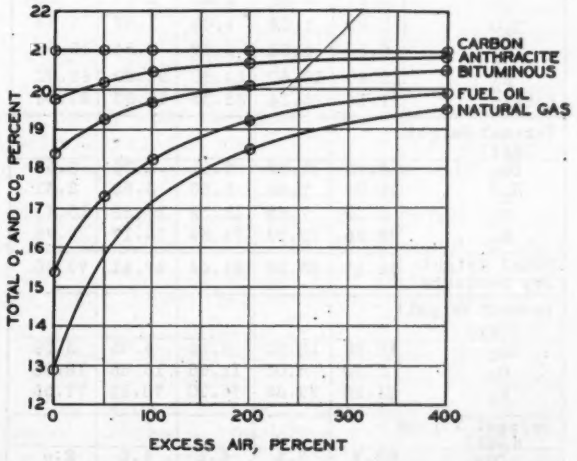


FIG. 2. TOTAL $CO_2 + O_2$, IN PER CENT BY VOLUME IS SHOWN FOR THE MAIN TYPES OF FUELS

*Dept. of Fuel and Gas Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

responding is found by use of the proportion 21 to 79. This gives $81.8 \times \frac{21}{79} = 21.8$ per cent O_2 (on a basis of "dry" flue gas).

Of this 21.8 per cent O_2, 7.4 per cent appears as CO_2, and 10.8 per cent as O_2. The remainder, 3.6 per cent O_2, is in the form of H_2O. One molecule of O_2 forms two molecules of H_2O, so the water content of the flue gas is 7.2 volume-per cent of the dry gas.

When excess air is added to a flue gas from a fuel with a large amount of net hydrogen, the sum of CO_2 plus O_2 is intermediate between the 21 per cent corresponding to infinite excess air, and the total oxygen corresponding to perfect combustion with no excess air. The two extreme cases are pure carbon and hydrogen gas. In the case of carbon, the sum of CO_2 and O_2 is always 21 per cent, independent of the amount of excess air used. Coals low in hydrogen, such as anthracite, approach this condition. On the other hand, with pure hydrogen burning with no excess air, gas analysis would show 100 per cent nitrogen. Natural gas contains a large amount of hydrogen, and of the common industrial fuels, most nearly approaches this condition.

Table I shows the ultimate analysis of several representative fuels of different hydrogen contents, on a moisture- and ash-free basis. In Table II, theoretical gas analyses are shown for complete combustion with different percentages of excess air. Values of the two extreme cases, anthracite coal and natural gas, are plotted in Fig. 1, and the totals of CO_2 and O_2 for all main types of fuels are shown in Fig. 2.

The great influence of net hydrogen in the fuel is shown by Fig. 2, which also shows that with a large amount of excess air the total apparent oxygen is increased, approaching 21 per cent. This follows the general principle that the composition of a mixture tends to approach that of the increasing material.

TABLE III. TO SHOW THE METHOD OF ARRIVING AT THE THEORETICAL CO_2 AND O_2 FOR ANY FUEL, THESE FIGURES WERE WORKED OUT FOR NATURAL GAS

Weight Products Perfect Combustion	Complete Combustion of Natural Gas				
	Percent Excess Air				
	0	50	100	200	400
CO_2	2.87	2.87	2.87	2.87	2.87
H_2O	1.89	1.89	1.89	1.89	1.89
O_2	0.00	1.88	3.77	7.54	15.08
N_2	12.40	18.60	24.80	37.20	62.00
Total	17.16	25.24	33.33	49.50	81.84
Percent Weight (Wet)					
CO_2	16.73	11.37	8.61	5.79	3.50
H_2O	11.02	7.48	5.68	3.82	2.31
O_2	0.00	7.45	11.32	15.22	18.41
N_2	72.25	73.70	74.39	75.17	75.78
Total Weight Dry Products	15.27	23.35	31.44	47.61	79.95
Percent Weight (Dry)					
CO_2	18.80	12.30	9.12	6.03	3.59
O_2	0.00	8.05	11.98	15.85	18.86
N_2	81.20	79.65	78.90	78.12	77.55
Percent Volume (Dry)					
CO_2	12.9	8.5	6.1	4.0	2.4
O_2	0.0	7.4	11.0	14.5	17.1
N_2	87.1	84.1	82.9	81.5	80.5

TABLE III SHOWS METHOD OF COMPUTING THEORETICAL CO_2

To show the calculations in Table II on a weight basis, Table III has been calculated for the case of natural gas with the analysis: 78.2 per cent carbon, 21 per cent hydrogen, and 0.8 per cent nitrogen by weight.

Oxygen unites with carbon and hydrogen in the following proportions:

$$C + O_2 = CO_2$$
$$12 + 32 = 44 \text{ lb.}$$
$$2H_2 + O_2 = H_2O$$
$$4 + 32 = 36 \text{ lb.}$$

One pound of fuel contains 0.782 lb. of carbon which unites with $0.782 \times \frac{32}{12} = 2.09$ lb. of oxygen to form 2.87 lb. of CO_2. The hydrogen, 0.210 lb. unites with $0.210 \times \frac{32}{4} = 1.68$ lb. of oxygen to form 1.89 lb. of H_2O.

The total oxygen required for complete combustion is $1.68 + 2.09 = 3.77$ lb. With each pound of oxygen in the air is associated 3.29 lb. of nitrogen, so that the nitgrogen corresponding to complete combustion is 12.40 lb. The 0.008 lb. N_2 in the fuel may be neglected.

Hydraulic Turbines Ordered for Conowingo

FOR THE power development which is taking place at Conowingo on the Susquehanna River, three hydro-electric turbines have been ordered from the I. P. Morris department of the William Cramp & Sons Ship and Engine Building Co. of Philadelphia. The power which is generated at this plant will be used in the system of the Philadelphia Electric Co.

Each of these units will have a capacity of 54,000 hp. and will be a vertical shaft design. In physical dimensions, they are reported to be the largest hydraulic turbines yet constructed. The head under which these turbines will operate will be 89 ft., and the speed will be 81.8 r.p.m. The water will enter the turbines through plate steel casings of volute or spiral shape and the draft tubes to the tailrace will be of Moody spread type molded in concrete and lined at the top with plate steel. Each draft tube will have a central cone or core extending up to the runner.

Water entering the turbine casing will pass through large valves of the butterfly or pivot type, the internal diameter of the valves and of the entrance to the turbine casing being 27 ft. The runners or rotating elements of the turbines will be of cast steel built in sections; they will have an outside diameter of 17 ft. 9 in. The horizontal over-all distance across the plate steel casing will be 62 ft., and successive units will be spread apart a distance of 72 ft. from the center of one unit to the center of the next.

Interpretation of Boiler Water Analysis

By D. C. Carmichael

MOST BOILER waters under a soda treatment will be composed of the following salts or chemical materials: NaCl—Sodium chloride or salt; Na_2CO_3—Sodium carbonate or soda ash; NaOH—Sodium hydrate or caustic soda; Na_2SO_4—Sodium sulphate; $CaCO_3$—Calcium carbonate or chalk and organic matter. The calcium carbonate exists in much larger quantities with internal treatment than with external treatment where filters are provided for the raw water after being treated. The sodium chloride is found naturally or is formed from magnesium chloride or calcium chloride in the raw water. At any rate, all chlorides in the raw water will be converted to salt under the influence of a soda treatment.

The sodium carbonate is due to the treatment and the caustic soda is formed by the breaking up of the soda ash by the influence of heat and pressure within the boiler.

Just what reactions take place in the conversion of the sodium carbonate to caustic soda are not clearly known, but the amount of organic matter in the water seems to have a pronounced effect upon the amount of caustic soda present. In boiler waters having a large amount of organic matter, there is a very slight conversion of the sodium carbonate to caustic, as compared with small amounts of organic matter present.

According to J. H. Paul in his book "Boiler Chemistry and Feed Water Supplies," the conversion to caustic may take place as follows:

$$Na_2CO_3 + H_2O = NaCHO_2 + NaO\,H + O$$

$$2(NaCHO_2) + H_2O = Na\,C_2H_3O_2 + Na\,OH + O_2$$

Sodium formate and sodium acetate are both organic salts, and it may be due to the presence of organic matter in the raw water that these reactions forming these organic salts are not allowed to run to completion, thus converting the sodium carbonate to caustic soda. The amount of organic matter present in raw water, as mentioned before, may have a large bearing on the completion of these reactions. The sodium sulphate is formed by the interaction of the calcium and magnesium sulphates with the soda ash. In chemical terms the reaction takes place as follows:

$$CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4$$

In practically all cases in the writer's experience the relation of sodium sulphate to sodium chloride is fairly constant, so that the salt present may be used as an index to the quantity of sodium sulphate in solution. Inasmuch as the sodium sulphate makes up a large percentage of the total solids of most boiler waters, it is reasonable to believe that it is one of the most active causes for priming. Therefore, it becomes necessary to remove this salt by blowing down frequently.

The amount of priming that may occur is a direct function of the salt (sodium chloride) concentration, and once this point is determined, it is an easy matter to regulate the blow downs accordingly.

A rough analysis of the boiler water may be obtained by titrating with phenolphthalein and methyl orange as indicators for the sodium carbonate and caustic sodas; also using the same sample of water for determining the amount of sodium chloride present by titrating with silver nitrate and potassium chromate as the indicator. The boiler water of different boilers in a certain plant were titrated as described above with the following readings:

Pht	NaCl	Factor
14.0	17.5	1.25
29.8	38.0	1.27
24.0	30.3	1.26
14.0	18.0	1.28
16.5	24.5	1.48
8.6	10.7	1.24
16.9	20.0	1.18

The pht. reading was obtained by titrating with sulphuric acid of such strength as to give reading in grains per gallon of calcium carbonate equivalent, and the same with silver nitrate to give grains of sodium chloride per gallon. These readings show that the water in the boilers had not concentrated to the same strength, but by dividing the sodium chloride readings by the pht. alkalinity, an average factor of 1.28 is obtained, showing that the same relation exists between the alkalinity and chlorides of each boiler. These readings show which boiler is evaporating the most water, and in case of priming, this boiler would require the most blowing down.

A qualitative test with ammonium oxalate solution for showing the presence of scale forming salts can also be made on the boiler water, and also show what effect the soda is having on the scale when an internal treatment is used. The test is indicated according to the density of the precipitate whether heavy, light or medium. The precipitate will become lighter as the point of using the proper amount of chemicals for overcoming the scale forming matter is approached.

Government Reports Water Power Development During 1925

During the year 1925, the amount of water power development in the United States showed a great increase, according to a report recently issued by the Department of the Interior, through the Geological Survey. According to this report the capacity of water wheels in plants of 100 hp. or more on the first of this year was 11,176,596 hp., an increase of 1,138,941 hp., or about 11.5 per cent between March, 1925, and January 1, 1926.

During the past 17 yr. the capacity of water wheels in water-power plants has more than doubled. For 1908 the capacity was 5,339,391 hp.

California, for years second in amount of developed water power, is now the leading state, with 1,834,980 hp. in water power plants, and New York, with 1,750,391 hp., drops to second place in water power development.

Edward Dean Adams has given $100,000 to Engineering Foundation and the Engineering Societies Library for carrying on the work of those organizations. Mr. Adams has served as vice-chairman of Engineering Foundation for 10 yr. and has been elected an honorary member for life. An endowment committee has been appointed for Engineering Foundation consisting of its officers and representatives from the Founder Societies to maintain a well-considered plan to get larger resources for Engineering Foundation and the Engineering Societies Library as their opportunities for service develop.

Operating Boiler Tests Show Important Relations

Variation of Draft Loss, Superheat, Efficiency and Losses with Rate of Forcing and Percentage of CO_2

NUMEROUS tests are available of large boilers in big plants but data as to performance of small boilers such as are used in many industrial plants are scarce. As a contribution in this direction, engineers of the Heine Boiler Co. have reported results of a series of careful tests on one of its V-type water-tube boilers in use at the St. Joseph Gas Co. with analysis of the effect of changes of different factors. As these were not acceptance tests but solely to secure data for future guidance of the builders, no outside engineers were employed,

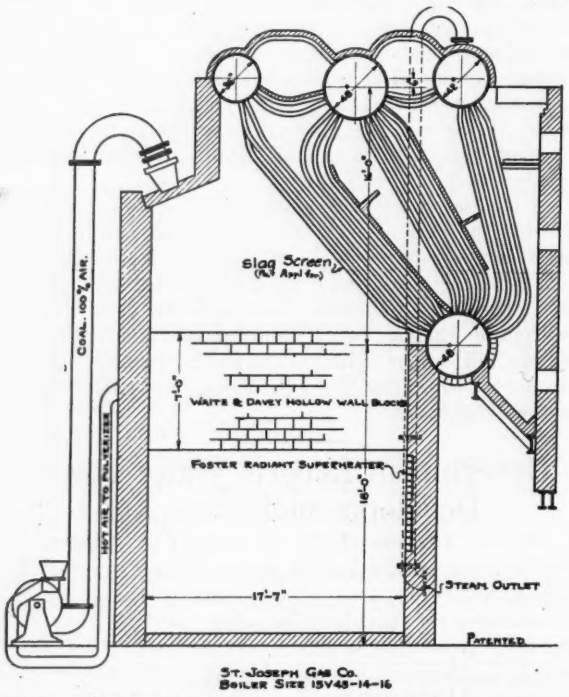


FIG. 1. THIS SETTING HAS AIR-COOLED SIDE WALLS, RADIANT SUPERHEATER AND PLAIN ASH-PIT FLOOR

but because of their purpose and the care in instruments and observations, there can be no question of the greatest accuracy possible.

Boiler and Equipment

This boiler was of 306 rated horsepower having 14 rows of 3¼-in. tubes deep and 16 ft. high from center of upper drum to center of bottom drum, as shown in Fig. 1. Side walls of the furnace are lined for 7 ft. below the boiler, 245.6 sq. ft. of surface, with Waite & Davey, air-cooled blocks made by Walsh Fire Clay Products Co. In the rear wall is a Foster radiant type superheater with 33.4 sq. ft. heating surface, 14 elements 7 ft. 2 in. long. The roof of the furnace is a slag screen on the bottom row of tubes and the bottom a refractory lining.

Pulverized fuel was used, burned in a single, downshot burner placed in the suspended arch in front of the boiler. All air for combustion was fed in with the fuel, 17 to 38 per cent being drawn through the hollow walls

TABLE I. TEST DATA WITH PULVERIZED FUELS ON 306-HP. WATER-TUBE BOILER AT ST. JOSEPH, MO. GAS CO.

Test No.	1	2	3	4
Date, 1926	Mar. 24	Apr. 2	Apr. 2	Apr. 2
Duration, hrs.	8	6	6	6
Rating per cent, Boiler & Suptr.	166	176	170	171
Coal - Kind	Bit.	Bit.	Lig.	Bit.
Town	Scammon	Orient	Sandow	Bevier
County	Cherokee	Franklin	Milan	Macon
State	Kan.	Ill.	Tex.	Mo.
Moisture as fired, %	8.17	10.06	34.88	15.03
B.t.u. as fired, per lb.	11861	11507	7123	9492
B.t.u. dry basis	12917	12792	10938	11171
Analysis Dry Basis				
Fixed Carbon, %	54.60	53.86	43.04	44.28
Volatile, %	33.03	34.59	42.55	33.73
Ash, %	12.37	11.55	14.41	21.99
Sulphur	3.11	1.16	2.01	6.02
Combustible in Furnace Ash, %	0.34	0.46	1.72	0.87
" " Fly " "	44.35	26.05	9.21	16.56
" " Total " "	34.49	22.57	8.06	13.64
Flue Gas, CO_2 %	14.9	14.7	14.9	14.2
O_2 %	5.7	4.3	4.2	4.4
CO %	0.0	0.0	0.0	0.0
N %	81.4	81.0	80.9	81.4
Feed Water Temp. deg. F.	127	125	128	116
Steam Drum Press. lb. sq. in.	144.5	141.7	142.7	141.7
Drop in Dry Pipe & Suptr. lb.	2.7	5.3	4.2	3.8
Per cent Moisture, leaving drum	0.3	0.5	0.6	0.4
Steam Temp. leaving Suptr. deg.F.	483	469	444	461
Superheat deg. F.	120	110	84	101
Flue Gas Exit Temp. deg. F.	584	598	597	598
Steam Temp. deg. F.	363	361	360	360
Difference deg. F.	221	237	237	238
Furnace draft in. water	0.01	0.02	0.04	0.04
Damper draft in. water	0.07	0.12	0.18	0.18
Draft loss in. water	0.06	0.10	0.14	0.14
Air through hollow walls %	--	29	17	25
Air lb. per hr. per sq. ft. exposed to furnace	--	5739	3994	5102
B.t.u. through hollow walls per sq. ft. per hr.	--	2196	1289	1513
Efficiency %	72.5	73.2	69.2	75.5
Dry flue gas loss %	11.2	12.0	12.5	11.8
Vapor in flue gas loss %	5.3	5.5	10.9	5.6
Unburned combust. loss %	7.3	3.9	1.7	4.6
Radiation and unaccounted %	3.7	5.4	5.7	2.5

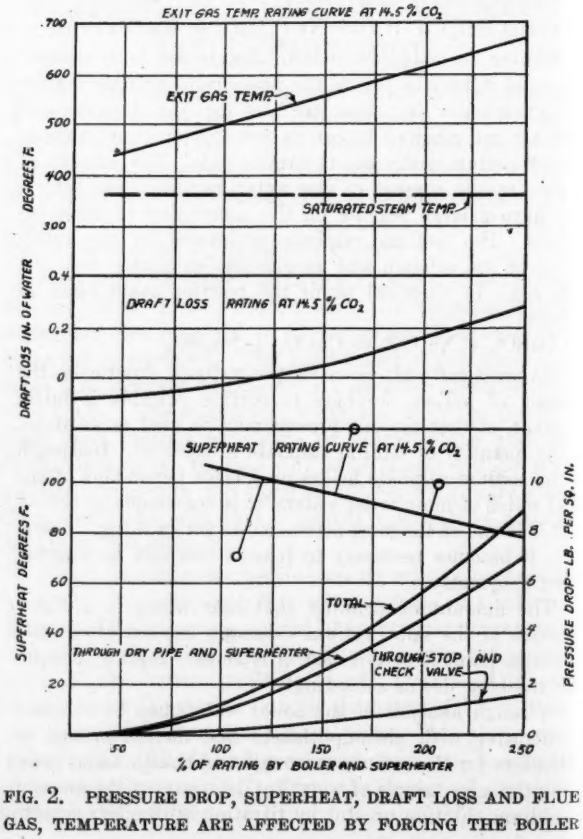

EXIT GAS TEMP. RATING CURVE AT 14.5% CO2
EXIT GAS TEMP.
SATURATED STEAM TEMP.
DRAFT LOSS RATING AT 14.5% CO2
SUPERHEAT RATING CURVE AT 14.5% CO2
TOTAL
THROUGH DRY PIPE AND SUPERHEATER
THROUGH STOP AND CHECK VALVE
DEGREES F.
DRAFT LOSS IN. OF WATER
SUPERHEAT DEGREES F.
PRESSURE DROP-LB. PER SQ. IN.
% OF RATING BY BOILER AND SUPERHEATER

FIG. 2. PRESSURE DROP, SUPERHEAT, DRAFT LOSS AND FLUE GAS, TEMPERATURE ARE AFFECTED BY FORCING THE BOILER

and heated up to from 295 deg. to 455 deg. F. The balance of the air is drawn from the boiler room and mixed with the heated air in the burner, the mixture of air and coal entering the furnace at temperatures of from 104 to 167 deg. F.

The boiler was designed for 150 lb. gage pressure and 75 deg. superheat with feed water at 120 deg.

Conditions of Tests

Six main tests were run, three of 7 hr. each at 110, 166 and 210 per cent of rating, CO_2 about 14.5 per cent and three of 3.5 hr. each at 171 per cent rating, with CO_2 at 8.5, 10.4, 12.1 and 14.9 per cent. In these a bituminous coal was used from Scammon, Cherokee Co., Kansas.

Afterward three tests of 6 hr. each were run, one with Franklin Co., Ill. coal; one with Milan Co., Texas lignite; one with Macon Co., Missouri bituminous coal.

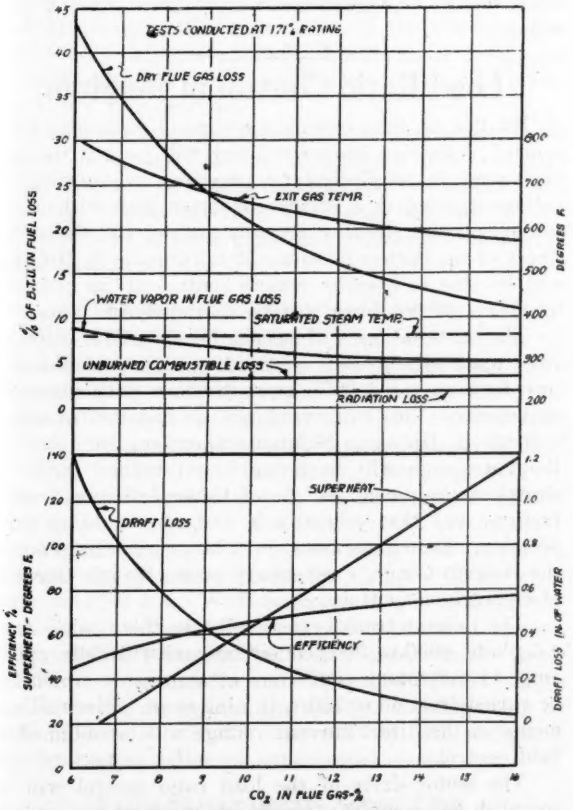


FIG. 3. EFFICIENCY, SUPERHEAT, DRAFT LOSS, FLUE GAS LOSS ARE ADVERSELY AFFECTED BY LOW CO_2

Although these coals would be considered troublesome to pulverize and burn, at no time was there difficulty in keeping CO_2 well above 14 per cent without CO or secondary combustion nor was there trouble in pulverizing to the desired fineness with the Aero Pulverizer used. No slag accumulations formed on sides or bottom of furnace nor on boiler or superheater tubes.

Feed and blowoff lines were checked for leakage and found tight, no blowoff or soot blowers being operated during a test run. Water was weighed as fed and coal before going to the pulverizer.

Main data from four of the tests with different coals were as shown in Table I. Comparison of other data is given in the form of curves.

Factors Varying with Boiler Power Developed

As shown in Fig. 2, pressure drop through the stop valve is small and increases but little with power developed, while drop through dry pipe and superheater varies approximately as the square of power developed.

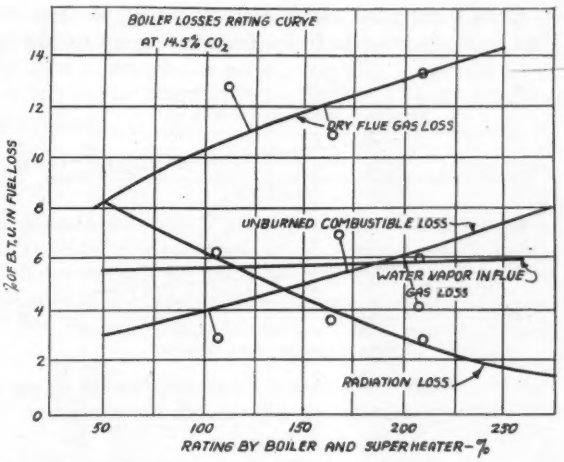

BOILER LOSSES RATING CURVE AT 14.5% CO2
DRY FLUE GAS LOSS
UNBURNED COMBUSTIBLE LOSS
WATER VAPOR IN FLUE GAS LOSS
RADIATION LOSS
% OF B.T.U. IN FUEL LOSS
RATING BY BOILER AND SUPERHEATER-%

FIG. 4. FORCING A BOILER INCREASES FLUE GAS AND UNBURNED COMBUSTIBLE LOSS

Total drop is, however, low, amounting to only 8.5 lb. at 250 per cent of rating.

While superheat varied irregularly with per cent of rating, a mean line seems to indicate a straight line relation, dropping from 104 deg. at 100 per cent to 78 deg. at 250 per cent, although the indications are not conclusive.

Draft loss and exit gas temperature both increase with per cent of rating. Draft loss is low as would be expected in a boiler only 14 rows deep and at rating is less than the chimney effect of the boiler setting. Exit gas temperature is higher than would be found with a deeper boiler, being 315 degrees above steam temperature at 250 per cent of rating. Both these curves are for CO_2 at 14.5 per cent.

Variation of Factors with CO_2

Figure 3 shows the effect of varying carbon dioxide on various elements of performance. Superheat increases nearly in straight line relation and draft losses decrease, although in varying relation, as CO_2 increases. The curves in the lower diagram show strikingly the importance of maintaining high CO_2 if high superheat and low draft loss are to be secured.

This is further emphasized by the upper diagram of Fig. 3. Exit gas temperature drops rapidly with high CO_2, from 726 deg. at 8 per cent to 580 deg. at 15 per cent. Water vapor, unburned combustible and radiation losses are small and depend little on CO_2 as they are due to other causes. But flue gas loss is increased tremendously by low CO_2 running up to 29 per cent of the heat value of the fuel when CO_2 drops to 8 per cent, with accompanying loss of efficiency.

All curves of Fig. 3 are for 171 per cent of rating.

Losses and Power Delivered

Study of Fig. 4 shows the relative importance of losses and how they vary as power increases. At all points, the flue gas loss is the greatest of any but is relatively larger at rating than when the boiler is forced, provided the CO_2 is kept high. Unburned combustible loss increases rapidly, while water vapor loss is nearly constant and radiation loss becomes relatively less as more fuel is burned.

Comparing total losses with efficiency, as shown in Fig. 5, the increase in losses from rating up to 250 per

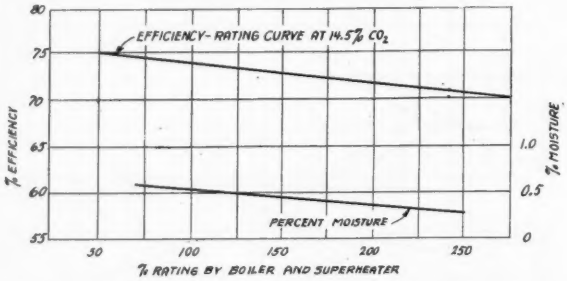


FIG. 5. WHILE EFFICIENCY FELL OFF SLIGHTLY, DRYER STEAM WAS MADE AT HIGH RATES OF OPERATION

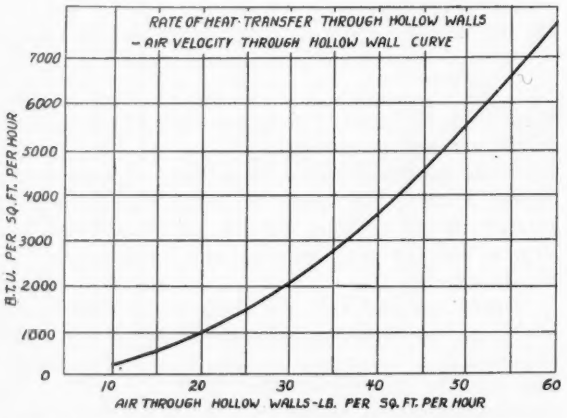


FIG. 6. HEAT TRANSFER IN AIR-COOLED WALLS IS INCREASED BY RAPID AIR FLOW THROUGH THE WALLS

cent of rating is found almost the same as the decrease in efficiency between those points confirming the accuracy of the tests and computations. Efficiency is good at all powers delivered for the character and size of unit under test. Dryness is well maintained even under hard forcing, the moisture being only 0.3 of one per cent at 250 per cent of rating.

Heat Transfer Through Walls

Data taken on the rate of heat transfer in hollow walls indicate that it varies as the velocity of air flowing through the walls. Figure 6 has therefore as a horizontal scale the pounds of air passing per hour over a square foot of heating surface exposed to the furnace. The vertical scale shows the rate of heat transfer per square foot of surface per hour. This will vary, of course, also with the temperature difference between air flowing and furnace gases but for this series of tests that difference would be practically constant.

To obtain data needed, temperature of the air was taken before it entered the hollow walls and, after it left them, in the duct leading to the pulverizer mill, thus avoiding radiation to or from the thermometer. To get the total air used for combustion, flue gas was analyzed and this, with the composition of the coal, the fly ash and the soot gave means to calculate the total air used for combustion. To determine what per cent of the total air used came through the hollow walls, temperatures were taken of outside air, of heated air in the duct to the mill and of air in the burner pipe. A small percentage of error is introduced by the heat absorbed by moisture in the coal in the pulverizer mill but not enough to alter results materially.

Such tests and analyses of results as above given are most valuable in determining the performance of equipment and pointing the way to improvements in design and method of operation. They are specially valuable when made, as were these, under daily running conditions.

Load Ratio Control in Belgium

By use of transformers equipped with load ratio control, a Belgian copper refinery will control the current used in its electrolytic processes by varying the voltage applied to a rotary converter, and without interrupting the circuit. By this method the Oolen Refinery of the Societe Generale Metallurgique de Hoboken will be able to exercise remote control of its processes by means of two push buttons on the control panel.

The installation will consist of two 915/1840-kw., 750-r.p.m., synchronous converters and two oil-cooled transformers rated 2055 kv.a., together with necessary switchgear. This equipment will be installed in a new refinery in Hoboken, Belgium, where copper from the Belgian Congo will be brought and refined. All the electrical equipment will be of General Electric manufacture, and that company is now also building three 4000-kw. motor generators for a large leaching plant in the Belgian Congo, a subsidiary of the Societe Generale Metallurgique de Hoboken.

The Belgian transformers will take their power from a 3-phase, 6600-v., 50-cycle circuit and will deliver 5270 amp. to the rotary converters at a pressure which can be varied from 66 to 130 v. in nine steps. Finer adjustments in the direct current voltage will be obtained by field control.

The motor drive of the load ratio control will accomplish one complete tap change in about ten seconds. It will be possible to operate the tap-changing mechanism by hand, with the motor disconnected. On the switchboard there will be an indicating instrument to show the attendant on which tap the transformer is operating.

Work has been begun on a new dormitory at the Worcester Polytechnic Institute, Worcester, Mass., made possible through generous contributions, among the largest being that of the late R. Sanford Riley, head of the Riley Stoker Corp. of that city. The building will bear his name. Mr. Riley was graduated from the institution in 1896. Ground was broken for the new building with appropriate ceremonies by Mr. Riley's son, Conrad Milton Riley.

Packing Glands for Large Steam Turbine Shafts

CARBON RING, WATER SEAL AND LABYRINTH GLANDS, OR COMBINATIONS OF THEM TOGETHER WITH GLAND HEATERS, FORM IMPORTANT ITEM IN SUCCESSFUL OPERATION

IN STEAM TURBINES, at points where the shaft passes out of the casing, it is necessary to provide packing glands to prevent leakage and loss of steam and, in case the pressure inside the turbine is less than atmospheric, to prevent entrance of air which would destroy the vacuum. Packing glands must also be used between the stages of an impulse type turbine and between the shaft and the diaphragms to prevent leakage of steam at those points.

In the operation of a steam turbine, proper functioning of the glands is of the greatest importance for continuous successful operation and for minimizing external losses. With this idea in mind, turbine manufacturers have given considerable attention to the glands and, in the case of turbines now on the market, practically no trouble is experienced with them if they are properly installed and operated according to the manufacturer's specifications.

It is the purpose of this article to discuss briefly the details of some of the packing glands used on large steam turbines, such as those of 20,000 kw. capacity and upwards. Some reference will also be made to the methods of condensing gland steam leakage by means of gland heaters.

CARBON RING PACKING GLANDS

Carbon ring packing glands have been used on all types of turbines for the steam and exhaust ends which on condensing units are steam sealed; they have also been used for packing diaphragms. Such glands consist essentially of one or more carbon rings, usually divided into three or four equal segments. These segments encircle the shaft surface and, by means of garter springs, are pressed to it or to a steel liner shrunk on the shaft. The cold radial clearance of 0.001 in. to 0.002 in. per in. of shaft diameter may become less than 0.0005 in. when the turbine is hot. With this type of gland, there is a possibility that high pressure superheated steam, as used in the modern large turbine, may disintegrate the material, causing increased wear. To guard against this, a steel liner may be used on the shaft or the rings may be made of some anti-friction material that will withstand this destructive action of superheated steam.

WATER SEALED GLANDS OFTEN USED

One of the best known types of packing glands in use today on the steam turbine is the water sealed gland, used either alone or in series with a steam sealed labyrinth or ring gland. Figures 1, 2 and 3 show typical examples of this construction as used on well-known steam turbines.

The water sealed gland, as shown in Fig. 1, consists of a centrifugal pump impeller attached to the turbine shaft and rotating within the gland casing. This pump is supplied with soft water under a slight head and produces a solid ring of water under pressure to form a hermetic seal against leakage. The gland illustrated in Fig. 1 is used on the high pressure end of the turbine but for the low pressure end a slight modification of it is necessary because of the high pressure at the gland caused by the low pressure balance piston. This modification consists in backing up the water sealed gland by a suitable labyrinth packing to prevent excessive leakage from the inside of the balance piston to the exhaust chamber. To insure the effective life of the gland, it should be supplied with water free from scale-forming substances or acids, otherwise, scale will be deposited in the gland chamber and may cause injury to the runner.

WATER SEALED GLANDS IN SERIES WITH LABYRINTH GLANDS

Glands shown in Figs. 2 and 3 are of the combined water sealed and labyrinth type. The water sealed gland is, in principle, the same as that just described. The steam packing, Fig. 2, is a throttling device consisting of one or more sets of stationary and revolving teeth,

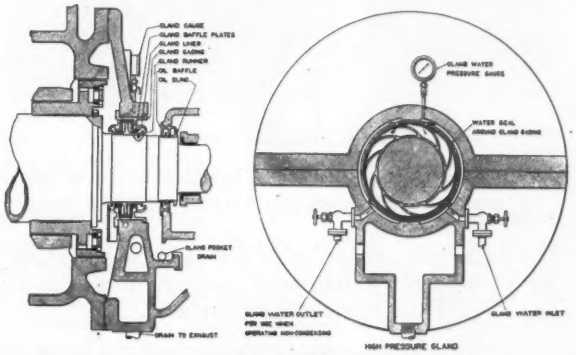


FIG. 1. THIS WATER SEALED GLAND IS USED ALONE ON HIGH PRESSURE END OF ONE TURBINE

assembled as shown, with small radial clearance. The teeth are machined on the surfaces of sleeves and rings, although older types of these packings had inserted teeth. In the gland shown in Fig. 2 teeth are also provided on each side of the impeller to increase the packing qualities, especially before the water is turned on.

If possible, condensate should be used for the water supply so that the heat of the steam may be utilized and scale formation prevented. If this is not possible, however, some other supply of pure soft water should be used. It is sometimes the custom to use a relief valve in the water supply line to the glands, set to hold a constant pressure of 5 or 10 lb. gage, or whatever is recommended for the gland in question. Piping should include stop valves, pressure gage and a thermometer well, so that proper flow, pressure and temperature may be maintained at all times.

During normal operation under load, the rows of teeth in the labyrinth packing take the greatest drop in pressure, although they do not seal completely against the pressure within the shell. The steam that leaks past the labyrinth flows into the chamber in the packing casing, as shown by the arrows in Fig. 2, which, in some cases, is connected to one of the lower stages of turbine, where its energy is utilized; in other cases, it is connected to a feed water heater, as will be explained later.

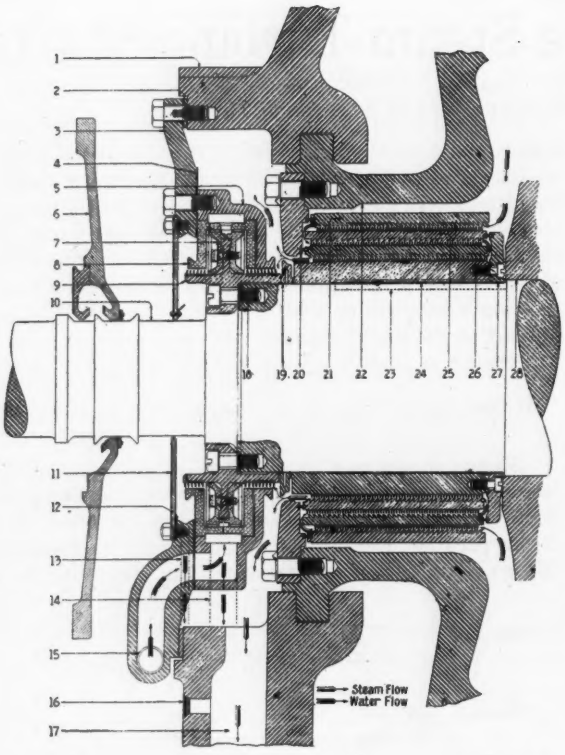


FIG. 2. WATER SEAL IN SERIES WITH STEAM LABYRINTH, STEAM LEAKAGE BEING DRAWN OFF BETWEEN THEM

The steam in this chamber is prevented from leaking to the atmosphere by the water packing, since it is at a pressure only slightly above atmospheric.

Methods of Operating

A certain flow of water should be maintained to prevent boiling in the impeller chamber. For economical use of water, the outlet valve should be set so that the outlet temperature is just a few degrees below the point at which the water would vaporize and escape. To get a sufficient flow of water to prevent steaming, it may sometimes be necessary to use a pressure of as much as 15 lb. gage in the impeller chamber. In the case of the gland shown in Fig. 2, minimum pressure recommended is 10 lb. gage.

When the turbine is being started or stopped and is not under load, the water supply should be shut off, since the speed of the impeller will not always be high enough to make the seal effective. With this type of gland, during starting or stopping a small amount of live steam can be supplied to the packing to prevent air from being drawn into the casing. Usually a pressure of 1 lb. gage is sufficient, although the operator may find by experience with a particular turbine that a little more is desirable.

In addition to this, during starting and stopping the valve in the pipe line connecting the packing chamber with the feed water heaters, if these are used, should be closed so that the sealing steam will not be drawn into the heaters instead of into the turbine shell.

In the case of the gland shown in Fig. 3, when it is used on the coupling end of the shaft, provision is made to take care of the small amount of leakage that may work along the turbine shaft. The inward leakage from the runner is drained away through the casing to prevent it from splashing on the spindle. Any outward leakage is also carried away by the drain in the cavity between the gland and the main bearing. This drain must be kept clear at all times, otherwise, water might flow into the bearings and contaminate the oil supply.

On the high pressure end, shown in Fig. 3, the steam labyrinth is provided, as shown, ahead of the water seal, with a space between for taking off the steam leakage. This leakage, however, is taken off only in case the pressure within the turbine cylinder is greater than that against which the gland can be made to seal, principal reliance being placed on the water seal.

Labyrinth Glands Are of Various Types

Labyrinth glands as shown in Fig. 4 are used on the large turbines of one manufacturer. These are designed to provide a long throttling path for the steam, thus reducing the pressure during its passage. In single labyrinth glands the projections protrude only from the casing to the shaft, while in the double labyrinth type rings on the rotating element mesh with grooves in the casing. Labyrinth packings are sometimes used on balance pistons on reaction and combination impulse-reaction turbines.

In the particular turbine gland shown in Fig. 4, the gland employs brass strips which do not quite touch the rotating element. These strips have knife edges, as shown, which can wear away without dangerous heating in case a slight axial displacement of the shaft should occur. No cooling or lubrication is required with this gland and the condensate remains free from oil.

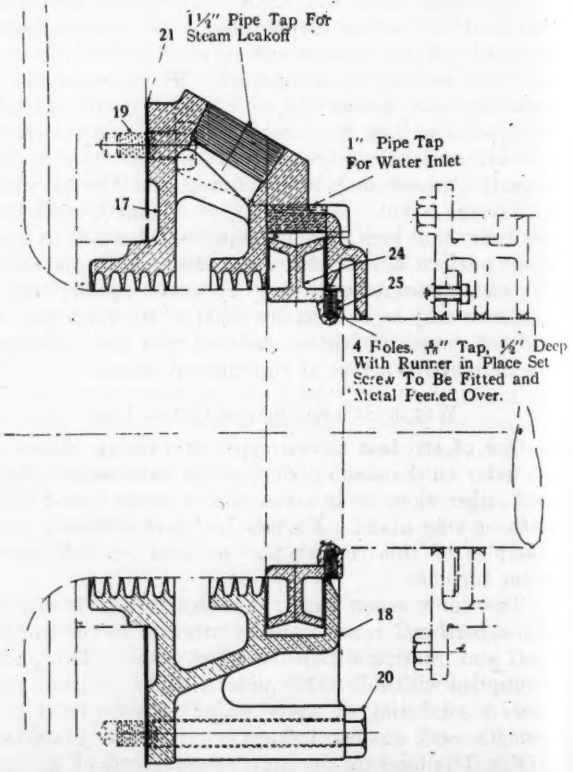


FIG. 3. ANOTHER TYPE OF COMBINED WATER SEAL AND LABYRINTH

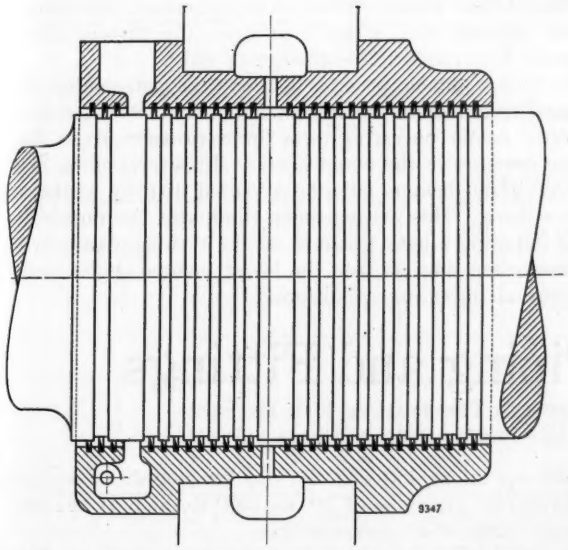


FIG. 4. STEAM LABYRINTH SHAFT GLAND USED BY ONE MANUFACTURER, WITHOUT WATER SEAL

At the high pressure end the difference in pressure is only that between atmosphere and the balance piston. For this reason, glands at both ends are normally under vacuum and are supplied with a small quantity of live steam to exclude air from the casing. Chimneys are mounted on the gland boxes to indicate the correct adjustment of the valves admitting steam to the glands.

Construction of the turbine on which these glands are used is such as to prevent relative displacement of rotor and casing. The leakage loss, therefore, has been found to be practically negligible.

Gland Heaters Condense Steam Leakage

In the discussion given above it was noted that steam leakage in the glands is sometimes led to feed water heaters. This is particularly true when a regenerative steam cycle is being employed in which feed water is heated by steam extracted from the turbine. Figure 5 shows the layout of extraction heaters used in a large power station, the gland steam heater being shown in the upper right corner. As shown in the diagram, the gland steam heater is vented and drained into the intermediate stage heater which, in turn, is vented and drained into the low stage extraction heater. The gland steam heater is protected from extreme temperatures by a desuperheater and the desuperheat water is taken from the main stream of condensate. In general, the heaters used for this purpose are the same in design and construction as the usual types of closed feed water heaters.

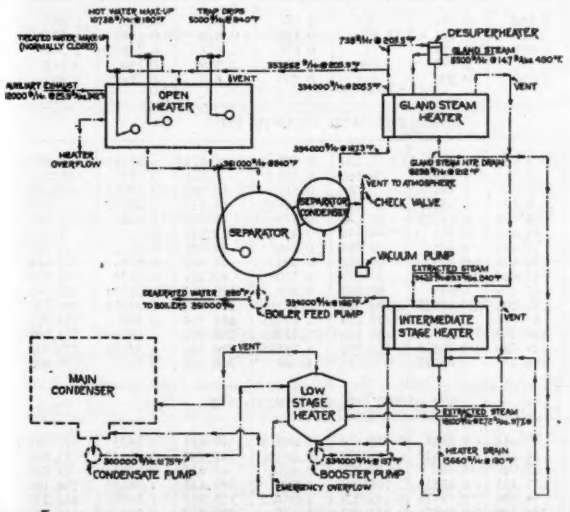


FIG. 5. TYPICAL LAYOUT OF EXTRACTION HEATERS IN A LARGE CENTRAL STATION

Desuperheaters Are Often Used With Heaters

Many users of gland steam heaters advocate the use of desuperheaters in connection with them as a precaution to protect the heater from the extremely high superheat temperature. At the same time, manufacturers of such heaters have provided equipment designed to stand

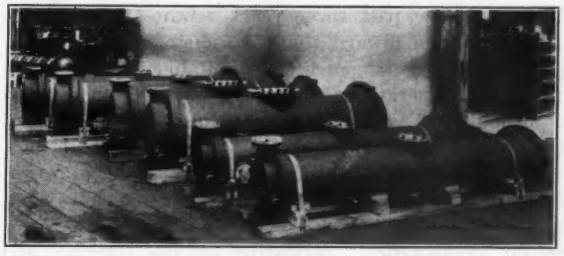


FIG. 6. SIX EXTRACTION HEATERS FOR 20,000-KW. TURBINES, THE NEAREST TWO BEING THE GLAND HEATERS

up under the strains imposed by the high temperature superheated steam, although stating that the heaters will necessarily give longer service with less attention if these strains are lessened by desuperheating. Desuperheaters may be arranged so that condensate from the gland steam heater acts as desuperheat water.

It is admitted by some heat transfer authorities that highly superheated steam does not always constitute a particularly good heating medium. This statement, however, has been subject to considerable argument, since many other authorities feel that, on the whole, the superheat has only a negligible effect upon heat transfer. It may be that the gland steam carries with it a higher percentage of air and non-condensable gases than does ordinary exhaust or extracted steam, thus affecting the heat transfer. In determining the size of the heater for condensing gland steam, therefore, this point should be considered and heat transfer rates should be employed that are rather conservative.

General Considerations of Gland Heaters

Pressure for which such heaters are to be designed is, in most cases, not more than 50 or 60 lb., which is about that generated by the hot-well pump in circulating the condensate through the tubes.

Several types of these heaters use the floating head construction to eliminate strains on the tubes and their fastenings and steel shells are commonly used. Several passes for the water are often provided and the tubes may be baffled to give good steam circulation. Provision is also made in several types of heaters for removal of the entire tube bundle from the heater without removing the tubes from the tube sheets.

Figure 6 shows a group of six extraction feed-water

heaters supplied by one manufacturer for the 20,000-kw. turbo-generators of a large central station. The two heaters nearest the reader are the gland steam heaters and it will be noted that, from their appearance, it is impossible to distinguish them from any other closed feed-water heater.

Most turbine manufacturers object to any back pressure on the turbine gland. For that reason it is usually advisable to install a separate heater to handle gland steam alone although, in a plant where motor-driven auxiliaries predominate, the exhaust from a spare turbine-driven boiler feed pump might be piped to the gland steam heater. Such an arrangement, however, is not common and, when it is used, the turbine-driven boiler feed pump is for emergency only.

It is common practice to vent the non-condensable gases from a gland steam heater into another closed feed-water heater operating on a lower pressure stage than the pressure in the gland heater. In several cases, however, gland heaters have been vented directly to the atmosphere. This arrangement eliminates the possibility of imposing a back pressure on the turbine glands or of short-circuiting air into the lower turbine stages under unusual operating conditions.

New Standards in Piping and Fittings

TENTATIVE STANDARDS FOR HIGH PRESSURE AND TEMPERATURE PIPE FLANGES AND FLANGED FITTINGS NOW READY FOR ADOPTION BY SPONSOR ORGANIZATIONS

DURING the past three years definite progress has been made toward the adoption of standards for pipe flanges and flanged fittings suitable for high pressures and temperatures, this work having been carried on through the American Engineering Standards Committee and the American Society for Testing Materials. Tentative standards, which have received the approval of the members of the Sectional Committee, have been drawn up and are now ready for approval by the three sponsor organizations, consisting of the Heating and Piping Contractors' National Association, the Manufacturers' Standardization Society of the Valve and Fittings Industry and the American Society of Mechanical Engineers. These cover working steam pressures from 250 to 900 lb. per sq. in. at a maximum temperature of 750 deg. F. They are also designed for maximum non-shock working hydraulic pressures from 325 to 1080 lb. per sq. in. at 450 deg. F. and for non-shock working hydraulic pressures of 500 to 1500 lb. at near the ordinary range of air temperatures.

With these standards well on the way to adoption, work has been started on the dimensional standards for flanges and fittings for 1300 lb. pressure.

Materials specified in these standards have undergone the most severe tests conceivable, physical tests, chemical analyses and microscopic examinations having been used to determine their fitness.

Copies of the "Tentative Specifications for Alloy-Steel Bolting Material for High Temperature Service" and "Tentative Specifications for Carbon Steel Castings for Valves, Flanges and Fittings for High Temperature Service" may be secured from the American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa.

In a serial report on Station Piping recently issued

TABLE I. TENTATIVE STANDARD DIMENSIONS AND WEIGHTS OF PIPE FOR HIGH TEMPERATURES

Nominal Pipe Size	Outside Diameter, Inches	Threads per Inch	250 Lb.		400 Lb.		400 Lb.		600 Lb.		900 Lb.		1350 Lb.	
			Wall Thickness, Inches	Weight per Linear Foot, Plain Ends	Wall Thickness, Inches	Weight per Linear Foot, Plain Ends	Wall Thickness, Inches	Weight per Linear Foot, Plain Ends	Wall Thickness, Inches	Weight per Linear Foot, Plain Ends	Wall Thickness, Inches	Weight per Linear Foot, Plain Ends	Wall Thickness, Inches	Weight per Linear Foot, Plain Ends
			SEAMLESS OPEN HEARTH PIPE				SEAMLESS OPEN HEARTH PIPE							
⅛	0.840	14	0.109	0.850	.....	.....	0.109	0.850	0.147	1.087	0.147	1.087	0.147	1.087
¼	1.050	14	0.113	1.130	.....	.....	0.113	1.130	0.154	1.473	0.154	1.473	0.1875	1.727
1	1.315	11½	0.133	1 678	.....	.....	0.133	1.678	0.179	2.171	0.179	2.171	0.21875	2.561
1¼	1.660	11½	0 140	2.272	.....	.....	0.140	2.272	0.191	2.996	0.191	2.996	0.250	3.764
1½	1.900	11½	0 145	2 717	.....	.....	0.145	2.717	0.200	3.631	0.200	2.631	0.28125	4.862
			LAP WELDED OPEN HEARTH PIPE				SEAMLESS OPEN HEARTH PIPE							
2	2.375	11½	0.154	3.652	0.218	5.022	0.167	3.938	0.1875	4.380	0.250	5.673	0.3125	6.883
2½	2.875	8	0.203	5.793	0.276	7.661	0.203	5.793	0.217	6.160	0.276	7.661	0.375	10.012
3	3.500	8	0.216	7.575	0.300	10.252	0.216	7.575	0.241	8.388	0.3125	10.638	0.40625	13.423
3½	4.000	8	0.226	9.109	0.318	12.505	0.226	9.109	0.28125	11.170	0.34375	13.423	0.46875	17.678
4	4.500	8	0.237	10.790	0.337	14.983	0.237	10.790	0.28125	12.672	0.375	16.520	0.500	21.360
5	5.563	8	0.258	14.617	0.375	20.778	0.258	14.617	0.352	19.590	0.4375	23.949	0.625	32.961
6	6.625	8	0.280	18.974	0.432	28.573	0.288	19.491	0.385	25.658	0.500	32.707	0.6875	43.596
8	8.625	8	0.322	28.554	0.500	43.388	0.34375	30.402	0.46875	40.832	0.625	53.400	0.875	72.424
10	10.750	8	0.365	40.483	0.500	54.735	0.395	43.684	0.53125	57.979	0.750	80.101	1.0625	109.930
12	12.750	8	0.375	49.562	0.500	65.415	0 500	65.415	0.625	80.935	0.875	110.973	1.21875	150.095
14	14.0	8	0.40625	58.980	0 625	89.279	0.500	72.091	0.65625	93.524	0.9375	130.790	1.34375	181.635
16	16.0	8	0.46875	77.754	0.6875	112.433	0.53125	87.771	0.750	122.154	1.03125	164.864	1.500	232.293
18	18 0	8	0.500	93.451	0.750	138.174	0.59375	110.379	0.8125	149.146	1.15625	208.002	1.6875	293.996
20	20.0	8	0.5625	116.772	0.875	178.725	0.625	129.330	0.90625	184.806	1.28125	256.146	1.84375	357.524
24	24.0	8	0.625	163*	0.9375	240*	0.750	186.235	1.03125	252.975	1.500	360.455	2.1875	509.602
SPECIAL SIZES			LAP WELDED OPEN HEARTH PIPE				SEAMLESS OPEN HEARTH PIPE							
4½	5.000	8	0.247	12.538	0.355	17.611	0.250	12.682	0.3125	15.644	0.40625	19.931	0.5625	26.658
7	7.625	8	0.301	23.544	0.500	38.048	0.3125	24.405	0.40625	31.320	0.5625	42.428	0.78125	57.105
9	9.625	8	0.342	33.907	0.500	48.728	0.375	37.046	0.500	48.728	0.6875	65.624	0.96875	89.561
15	15.0	8	0.4375	68.044	0.625	95.954	0.500	77.431	0.6875	105.091	1.000	149.522	1.40625	204.164
17	17.0	8	0 500	88.111	0.6875	119.776	0.5625	98.749	0.78125	135.327	1.09375	185.807	1.59375	262.237
22	22.0	8	0 625	148*	0.875	204*	0.6875	156.489	0.96875	217.597	1.375	302.882	2.000	427.206

*Hammer weld pipe approximate manufacturing weight.

TABLE II. PROPERTIES OF 1200-LB. STEAM PIPING INSTALLED AT EDGAR STATION

Nominal Size, Inches	Tubing or Piping			Normal Temperature			700 Deg. Fahr.		
	I.D., Inches	O.D., Inches	Thickness, Inches	Ultimate Strength	Bursting Pressure	Factor of Safety	Ultimate Strength	Bursting Pressure	Factor of Safety
Double Extra Heavy Pipe									
½	0.25	0.84	0.295	40,000	28,100	23.5	....	....	....
¾	0.43	1.05	0.31	40,000	22,800	19.0	....	....	....
1	0.60	1.315	0.36	40,000	21,800	18.2	....	....	....
2	1.50	2.375	0.437	40,000	14,700	12.3	....	....	....
3	2.30	3.500	0.60	50,000	17,100	14.2	....	....	....
Seamless Drawn Tubing									
4	3¼	4	⅜	60	11.3	9.4	67,000	12,600	10.5
5	4	5	½	60	12	10	67,000	13,400	11.2
6	5	6	½	60	10	8.3	67,000	11,200	9.3
7	6	7½	¾	60	12	10	67,000	13,400	11.2

Strengths are given in lb. per sq. in., and are calculated from data supplied by the National Tube Company.

by the Prime Movers' Committee of the National Electric Light Association, an excellent review of the present practice in the design, manufacture, testing and use of piping for power plants is given. The tentative specifications which are cited in this report for pipe flanges for high temperature service cover forged or rolled steel, contemplating temperatures up to 750 deg. F. or high temperatures with appropriate pressures at the discretion of the designing engineer.

Three classes of material are covered. Class A is intended for forge welding and is classified by the chemical properties. Classes B and C are classified according to their physical properties. The chemical composition of these classes is as follows:

	Class A	Class B and C
Manganese, per cent.....	0.35 to 0.60	0.40 to 0.80
Phosphorus, per cent.....	not over 0.05	not over 0.05
Sulphur, per cent.....	not over 0.05	not over 0.05

Class A material must not contain over 0.17 per cent carbon but classes B and C may have a carbon content which is agreed upon by the purchaser and the manufacturer.

Tensile properties of steel for flanges must conform to the following minimum requirements:

FLANGES NOT FOR FORGE WELDING

	Class B	Class C
Tensile strength, lb. per sq. in.....	60,000	70,000
Yield point, lb. per sq. in.....	30,000	36,000
Elongation in 2 in., per cent.....	25.0	22.0
Reduction of area, per cent.....	38.0	30.0

Class A steel does not require heat treatment but classes B and C must be subjected to heat treatment which may consist of annealing or normalizing.

Lap welded and seamless steel pipe for pressures of 250, 400, 600, 900, and 1350 lb. pressure are covered in proposed tentative specifications for pipe for high temperature service. This contemplates temperatures up to 750 deg. F. or higher with appropriate pressures at the discretion of the designing engineer. Such pipe must be suitable for bending, flanging and such forming operations. Low carbon steel tubing rather than medium carbon should be used for cold bending or fusing welding. The purpose for which each type is to be used should be stated on the face of the order.

It is stated in these specifications that the steel for lap welded pipe must be of soft weldable quality made by the open-hearth process, and the steel for seamless pipe must be made by the open-hearth or electric furnace process. The lap weld process only is specified for piping used for 2-in. nominal size and over, while for pipe 1½-in. nominal size and smaller, the seamless process is specified.

Following are the chemical requirements for steel used for welded and seamless pipe.

	Welded	Seamless
Phosphorus, per cent.....	not over 0.06	0.04
Sulphur, per cent.....	not over 0.05	0.05

As to the tensile strength of material for piping, the specifications give the following minimum requirements:

		Seamless	
	Welded	Low Carbon	Medium Carbon
Tensile strength, lb. per sq. in..	45,000	47,000	62,000
Yield point, lb. per sq. in.....	25,000	27,000	35,000
Elongation in 2 in., per cent..	40	40	25

Specifications require that the pipe should be tested with hydrostatic pressure, the pressures being as given in the table below. While the welded pipe is under pressure it is struck near both ends with a 2-lb. hammer or equivalent.

Class of Pipe Working pressure Lb. per sq. in.	Standard test pressures Lb. per sq. in.
250	750
400	1000
600	1500
900	2000
1350	3000

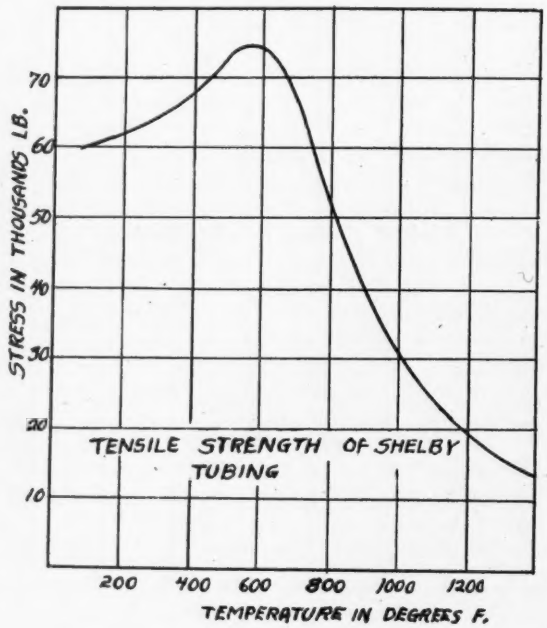
As representing pioneer practice in the design and specification of piping systems, the statement made by the Edison Electric Illuminating Co. of Boston regarding these features of the Edgar Station at Weymouth and given in the Station Piping report of the Prime

Movers' Committee will be found of great interest. What follows is an abstract of this statement dealing with the 1200-lb. system.

In planning the piping system for the 1200-lb. steam installation at the Edgar Station it was necessary to establish new designs for all parts, valves, fittings, flanged connections and piping, for there were no standards available. In carrying on this work use was made, as far as possible, of types that had demonstrated their reliability by actual successful service.

Pipe for 1200 Lb.

For piping material it was decided to use seamless drawn steel tubing for all sizes including 4 in. nominal and over, in order to insure homogeneity of material, chemical and physical properties. For the smaller lines double extra heavy mild steel pipe was adopted as giving



STRENGTH OF TUBING FOR 1200-LB. PIPING SYSTEM OF THE EDGAR STATION

ample strength and being more readily obtainable for work fabricated at the site.

The National Tube Co., makers of the tubing, give as the chemical analysis of the steel:

Carbon	0.15 to 0.20	per cent
Manganese	0.30 to 0.60	" "
Phosphorus, maximum	0.04	" "
Sulphur, maximum	0.05	" "

The minimum physical properties are given as follows:

Tensile strength, 58,000 lb. per sq. in.

Yield point, 45,000 lb. per sq. in. (77.5 per cent of T. S.)

Elongation in 2 in., 17 per cent.

Reduction of area, 30 per cent.

Variations of ultimate strength with changes of temperature are given by the curve shown herewith. The characteristics of the four sizes of tubing selected for the principal pipe lines are given in Table II, together with the bursting pressure at room temperature and at 700 deg. F. The bursting pressures for the smaller sizes of double extra heavy piping are also tabulated.

Stresses existing in the steam piping due to expansion at working steam temperatures were calculated from the behavior of a small model which was deformed a proportional amount. The calculated stresses for the actual installation amounted to a maximum of 1380 lb. per sq. in. in flexure and 1990 lb. in torsion.

Supports and anchors for the piping were laid out in accordance with the results of the tests on the model, the supports being of the spring type, and the anchors being of the guided type with one trunnion anchor at an inflection point.

Flanges

Design of the flanges and connections was based on the theory that the duty of the flanges is to maintain the gasket or welding faces in perfect alinement under the forces acting in service. The flanges were, therefore, designed for great rigidity and a series of tests were run on full-sized samples to determine the most satisfactory arrangement. These tests, which included Sargol welded and two gasket types, demonstrated that up to the bursting pressure of the tubing the deflection of the flanges was too small to be detected by standard micrometer calipers. The gasket connections proved satisfactory at both normal and operating temperatures up to the bursting pressure of the tubing, but it was found necessary to follow up the bolting owing to the initial set of the gaskets. The welded joint was free from this difficulty and was perfectly tight at all pressures. It was therefore chosen for both steam and water joints of 4 in. nominal size and larger. For the smaller joints the gasket design was used with a ring placed around the raised faces to retain the gasket.

For flanges on pipe 4 in. o.d. and larger, the Van Stone construction was adopted as the method of attachment. On smaller flanges for double extra strong pipe, standard pipe threads and welding at the back of the flange were used.

The Van Stone joint requires forging and is, therefore, subject to the possibility of affecting the strength of the pipe material during the flanging operation. Microphotographic studies indicated that the difficulties could be eliminated by forging at proper temperatures checked by pyrometer.

To protect the system against possible fracture of the Van Stone flanges of the tubes, the flanges were taper bored and the tubes rolled into them in much the same way that a boiler tube is rolled into its header. Tests of this construction on full-sized specimens proved conclusively that it affords ample protection against the pulling out of the tubing from the flanges. The taper alone is sufficient to give a factor of safety of 5 to 1 over the stress due to steam pressure.

For bolt material it was decided to use an alloy steel so as to minimize the loss of strength after a period of service at high temperatures. The steel adopted contains 0.3 to 0.5 per cent carbon.

Physical properties of typical bolts as shown by tests of random specimens are given below:

	Maximum	Minimum
Yield point, lb. per sq. in....	129,500	103,500
Ult. strength, lb. per sq. in...	155,000	126,000
Elongation in 2 in., per cent..	20.5	17.0
Reduction of area, per cent..	62.5	52.0
Brinell hardness	260	240

Chemical analysis of the same samples varied as follows:

	Maximum	Minimum
Carbon, per cent.....	0.46	0.33
Manganese, per cent.....	0.70	0.62
Nickel, per cent.....	0.99	0.57
Chromium, per cent.....	0.47	0.27
Phosphorus, per cent.....	0.025	0.011
Sulphur, per cent.....	0.034	0.022

Nuts were made of mild open hearth steel and case hardened in order to prevent the seizing of the nut to the bolt or flange after prolonged service.

Fittings

For nominal sizes of 4 in. and over, fittings were made of cast steel. For smaller sizes, forgings were used. The cast fittings differed in design from the standard practice only that near the flanges the thickness of the body was increased gradually and brought into the flanges with very large radius fillets. This was found necessary in order to prevent flaws in the castings at the point where the flanges joined the bodies. In order to check the quality of the castings all were subjected to examination by X-rays before being placed in service. In this way it was possible to eliminate castings containing defects which might have required replacement after a short period of service.

For instrument lines, fittings were formed from double extra heavy and mild steel pipe, using bends for elbows and gas welded outlets for tees. These parts were fitted with flanges of the four-bolt gasket type having a raised face and a retaining ring to prevent blowing out of the gaskets.

Valves

Valves 4 in. nominal size and larger were made with cast-steel bodies and bonnets, and forged trimmings. The design of the bodies was subject to the same modification regarding material thickness as the fittings. All castings subject to high temperatures were examined by X-rays.

Design of the valves does not differ materially from the standards for 300 to 400 lb. pressure, except that the parts are made heavier to withstand the increased pressures. Valve trimmings were made of Monel or an equivalent metal or of stainless steel.

All small valves were made of drop forgings, the trimmings being either of Monel or stainless steel.

Special types, such as safety valves and blowoff valves follow standard designs closely except for increase in strength. Tests on the safety valves have shown no abnormal cutting of seats, the valve remaining tight after being blown repeatedly at full steam pressure.

Gas Engine Competes with Motor Drive

Natural Gas Production in California Gives Impetus to Engine Development. By Claude C. Brown

SOMEWHAT IN EXCESS of 500,000 hp. of gas engines in operation in southern California use as fuel the natural gas as it comes from the oil fields with a calorific heat content of from 975 to 1200 B.t.u. per cu. ft. Installations have been increasing at the rate of about 50,000 hp. per yr., units varying in size from 2 or 3 hp. to 500 hp. or more and covering all fields where motive power is utilized. Taken as a whole, the load factor is relatively constant, remaining in the neighborhood of 60 per cent.

Great improvement in design within the last few years has placed the gas engine in a position which is practically on a par with the electric motor as far as reliability and economy of operation are concerned. Modern engines are now equipped with a substantial, positive and reliable system of high tension ignition that is continuous and uniform in its operation while practically all engines are now started by means of compressed air and equipped with forced feed lubricating system and throttle governors. Noisy exhaust has been overcome by mufflers which are not expensive and do not materially affect economy. Attendance, upkeep and repairs are surprisingly low as compared with the cost of these items in years past, due to the better workmanship and better materials used in construction.

In general the most economical and satisfactory engines are the slow speed two or four-cycle type designed to use natural gas through the medium of properly proportioned mixing boxes. Large numbers of the four-cycle units, mostly of 160 to 200 hp. capacity are utilized in the oil fields, connected to gas compressors for the purpose of pumping the natural gas from the fields through transmission lines to the centers of distribution. These engines are in continuous operation for long periods of time and have shown wonderful records of operation. High-speed multi-cylinder engines give excellent results under certain conditions but, as a rule, the fuel consumption, attendance, supervision, upkeep and repair costs of this type of engine is high as compared with the slow speed types.

The average cost of electric motor installations equipped with the usual starting and protective devices, but not including transformers will run about $15 per available horsepower. Gas engine plants properly installed and including air starting unit, muffler, gasometer, water circulating equipment, etc., complete will cost from $55 to $60 per available brake horsepower. Hence the comparative first cost of the gas engine is approximately four times as much as the electric motor.

Gas Engine Shows Saving in Fuel Costs

In order to determine the comparative operating costs of gas engine and electric motor, some tests were recently made at a plant where there were installed several gas engines and motors. At this plant a belted electric motor was used for the purpose of operating a deep well pump, rated to deliver 220 in. of water from a depth of 215 ft. A gas engine was installed at right angles

to the motor drive and so arranged that the belt could be shifted from the motor pulley to the gas engine jack shaft. A summary of the results is given in the accompanying tabulation:

COMPARISON OF GAS ENGINE AND MOTOR PUMPING COSTS FROM AN ACTUAL TEST

Power	160-Hp. Engine	150-Hp. Motor
Unit fuel cost	35.63 c per M. cu. ft.	1.129c per kw.
Cost gas, per hr. in.	0.353c	.....
Cost lub. oil, hr. in.	0.023c	.....
Total cost, per hr. in.	0.376c	.....
Energy charge, per hr. in.	.....	0.904c

Ratio of gas engine to motor costs 0.415.

Fixed charges applicable to a gas engine installation include interest, depreciation and repairs, while the operating charges include fuel, lubrication and labor.

FIG. 1. A TYPICAL GAS ENGINE-DRIVEN COMPRESSOR PLANT IN THE OIL FIELDS

Experience has shown that the average useful life of a gas engine properly maintained and kept up is from 20 to 25 yr. and that the fixed charges, namely, interest, depreciation and repairs, will average about 8 per cent of the capital investment per year. Thermal efficiency of a good gas engine will run about 25 per cent with a mechanical efficiency of about 90 per cent at its most efficient load.

At this efficiency a slow speed engine designed to use gas fuel with a properly designed arrangement for the mixing of the gas and air will develop from 1 hp. on 10 cu. ft. of natural gas. By using filtered oil, 3000 hp-hr. of operation per gallon of 20 to 35-ct. lubricating oil can be obtained per gallon. High-speed engines will use more lubricating oil, possibly one gallon for each 700 to 800 hp-hr., so a fair average would be 1000 hp-hr. per gallon of lubricating oil costing from 30 to 40 ct. per gal.

Labor for a good type of modern gas engine is practically the same as with an electric motor, inasmuch as present-day gas engines operate day in and day out without other attention than is necessary for the operation, maintenance and upkeep of the driven equipment, whether it be driven by electric motor or gas engine.

In order to net a return sufficient to warrant the installation and operation of a gas engine rather than a motor the plant must operate a considerable period each year to enable the fuel savings of the engine to balance the higher fixed charges. That is, if the total cost of motor and engine operation were plotted the curves would cross. Below the intersection it would be cheaper to operate a motor plant due to the low fixed charges while above this point the engine would be more eco-

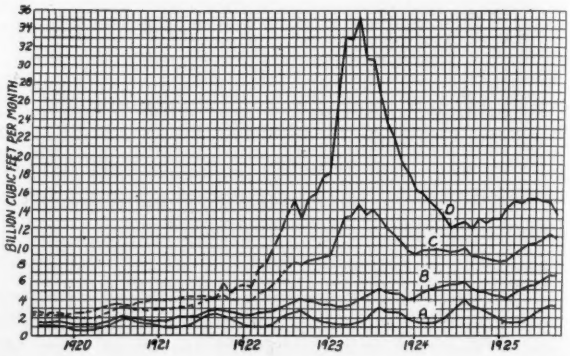


FIG. 2. GRAPHICAL REPRESENTATION OF CALIFORNIA'S NATURAL GAS PRODUCTION AND UTILIZATION

A. Total Domestic Sales. B. Total Domestic Sales Plus Total Industrial Sales. C. Total Domestic Sales Plus Total Industrial Sales Plus Total Estimated Field Use. D. Total Field Production

nomical due to low fuel costs. Under assumed power, equipment, fuel and oil costs as given the theoretical point of intersection would be about 750 hr. regardless of plant size, so to be economical an engine installation must operate in excess of this amount each year.

Actual rates and conditions peculiar to each installation will change this theoretical figure and determine the true value. Practically there is no established relation between the economical time of operation for one load as compared with that of another load, even though the same gas and electric rates apply to the different

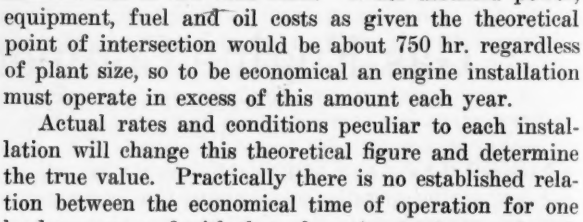
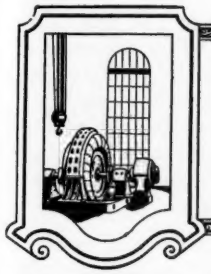


FIG. 3. HEAT CONSUMPTION OF A GAS ENGINE SHOWING INCREASE AT LIGHT LOADS

loads in question. At light load the engine thermal efficiency falls off rapidly as shown in Fig. 3 which will in turn have its effect on operating costs. Using actual sliding scale gas and electric power rates on the basis of 10 cu. ft. of gas per horsepower-hour, the point of equal cost for a 25-hp. load is 286 hr., while a 200-hp. load does not reach this point until operating 301 hr. Time, therefore, is an item which should receive serious consideration.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

A New Method of Lighting Outdoor Substations

LIGHTING UNIT EMPLOYING PRINCIPLE OF REFRACTION GIVES HIGH VERTICAL COMPONENT OF LIGHT WITH ABSENCE OF GLARE. BY DAVIS H. TUCK*

IN THE PAST, outdoor substations have been lighted by two radically different methods. The first method is the general overhead type of lighting such as is employed extensively for the interior illumination of industrial plants. The second method employs the use of flood lights focused on the most important parts of the structure. Both of these methods have decided drawbacks.

THE OVERHEAD SYSTEM

The general method of illumination is used to illuminate apparatus up in the structure, and the operator must look into the light to see the apparatus. The decrease in the ability to see when a light source against a black background is in the direct line of vision is too well known to comment upon. In short, the overhead method of lighting is correctly applied in the case of a factory where the objects to be viewed are at an approximate 3 ft. level above the floor, but is a misapplication in the case of the outdoor station. Not only is this method of illumination wrong from the illumination standpoint, but from a mechanical standpoint it is difficult and dangerous to maintain the lighting units when they are hung high above the ground close to the high tension parts.

THE FLOODLIGHT SYSTEM

In an effort to eliminate the glare and the danger attendant to maintenance, the floodlighting system has been tried for illuminating several stations. This system of illumination is expensive, produces dense shadows and does not eliminate glare.

Both systems therefore have disadvantages. The overhead system produces glare, is difficult and dangerous to maintain, is deficient in vertical illumination and in horizontal illumination on the underside of apparatus. The flood lighting method also produces glare as well as sharp shadows and undergoes a rapid permanent depreciation. Against these disadvantages must be placed the advantage of low cost for the overhead system and good vertical illumination and easy relamping for the flood lighting system.

In order to combine the advantages of both the overhead and flood systems of lighting and to eliminate the disadvantages of both in a new system of lighting for outdoor substations, a list of the desirable qualities was drawn up as follows in the relative order of their importance:

1—High vertical component of light.
2—Absence of glare.
3—Accessibility for relamping.
4—Absence of sharp shadows and dark pockets.

FIG. 1. NEW SUBSTATION UNIT HAVING A WIDE SPREAD OF UPWARD LIGHT

5—Low permanent depreciation.
6—Low initial and maintenance cost.
7—Flexible light distribution to suit various conditions of station design.

The unit which has been designed for this service is shown in Fig. 1 and its light distribution is shown in Fig. 4. The unit employs the principle of refraction rather than reflection because by refraction the wide angle light distribution required can be realized and dust-tight construction is practical. The units are mounted either on the first cross girder on brackets or on cast-iron posts located between columns in positions that will

*Electrical Engineer, Holophane Co.

not interfere with the movement of transformers and other apparatus.

Figure 2 shows the complete unit and indicates the general direction of the refracted light. It is to be noted that due to the high candlepower values at small angles to the horizontal, the vertical illumination component will be high. Spill light from the refractor which is not controlled by the refracting prisms is useful in illuminating the ground. Figure 4 (solid line) shows the distribution curve for lamp adjusted for position to give the angle of maximum candlepower at 110 deg. The dotted lines show the limits through which the angle of maximum candlepower may be varied by changing the socket position of the lamp. This change is easily and quickly made while the lamp is burning by simply loosening locknut A (Fig. 2) and turning the whole unit, thereby raising or lowering the lamp with reference to the refractor. The exact angle of maximum

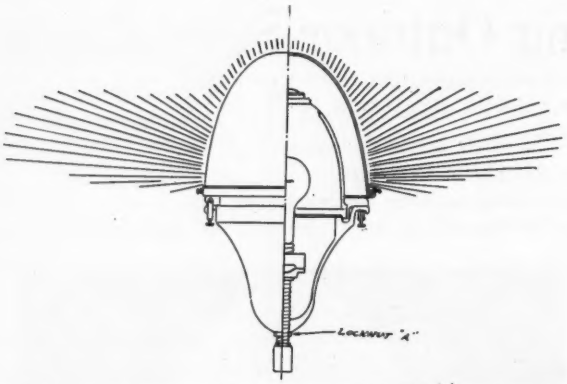


FIG. 2. CROSS SECTION OF THE SUBSTATION UNIT SHOWING CONSTRUCTION OF TWO-PIECE REFRACTOR AND BLOWN GLOBE

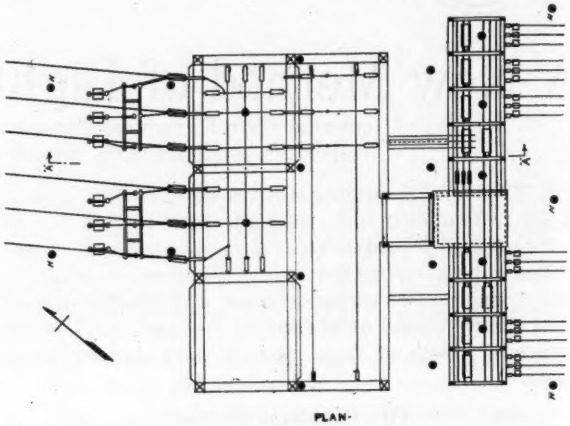


FIG. 3A. PLAN OF SUBSTATION SHOWN IN FIG. 3, ON A SMALLER SCALE

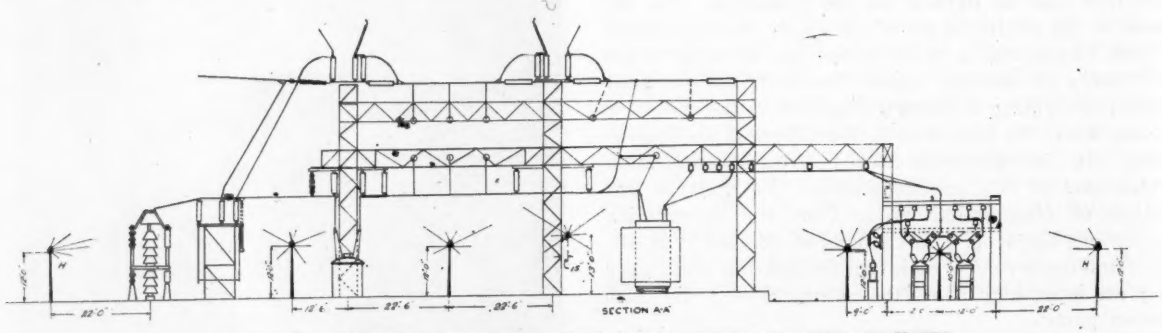


FIG. 3. ELEVATION OF TYPICAL SUBSTATION SHOWING SPACING OF UNITS

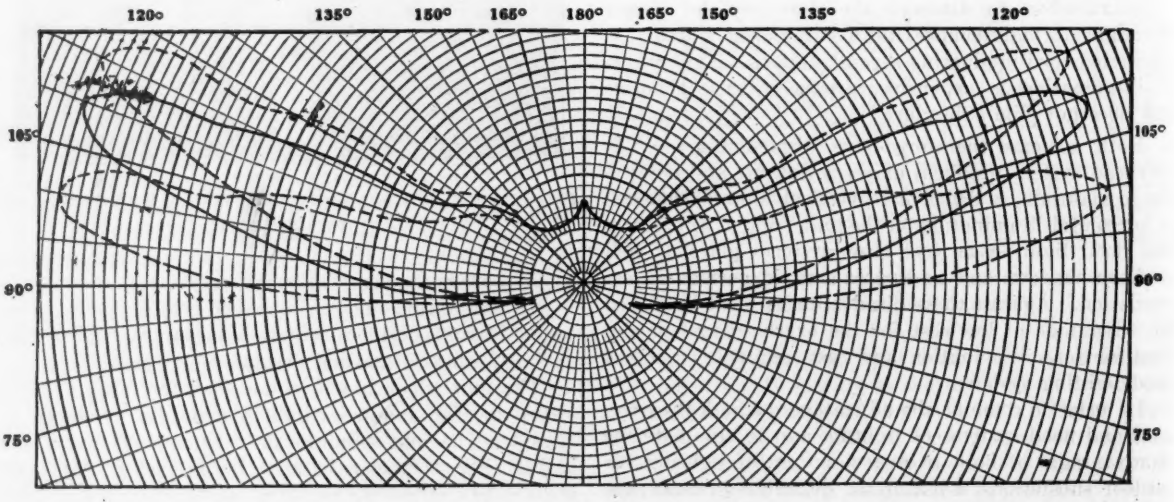


FIG. 4. LIGHT DISTRIBUTION OF NEW SUBSTATION UNIT TAKEN IN A VERTICAL PLANE. THE ANGLE OF MAXIMUM CANDLE POWER CAN BE CHANGED FROM 100 TO 115 DEG. BY LOOSENING BOTTOM LOCKNUT AND TURNING THE COMPLETE UNIT

candlepower for any condition will be between the limits of 115—100 deg. and can be set correctly on the job.

The wide light distribution insures good overlapping in distribution so that the apparatus in each bay receives light for all of the adjacent bays. In this way, a shadow that is cast by an opaque object in the path of the beam of light from one unit is illuminated by several adjacent units.

Glare is eliminated by refracting the light from the lamp upward, so that it falls on the structure instead of in the eye. The operator looks in the direction along with the light instead of against it. It has been found by test that the units should be mounted not less than 8 ft. above the ground. The exact height of the unit above the ground is found by drawing a line from the part to be illuminated to the lighting unit. The height of the unit should be such that the angle formed by this line and the axis of the lighting unit should be between 65—80 deg. The cast-iron post that has been made for this use is from 8 to 20 ft. high and brings the top of the unit from 9 to 21 ft. above the ground. When units are mounted on posts, lead covered twin conductor park cable is buried in the ground and brought up inside the post and up through conduit to the switch box. By keeping the lighting units about 10 ft. from the ground, danger of contact with high voltage when relamping is eliminated.

It will be noted from Figs. 1 and 2 that the unit is constructed to minimize temporary dust and dirt depreciation and the heavy galvanized cast-iron housing and triple clear crystal glass refractor and globe will stand up in all kinds of weather conditions. The lamp is sealed completely from the outside air so that dirt cannot accumulate either on the lamp bulb or on the inside surface of the refractor. The refractor is made in two pieces, permanently locked together, so that all of the refracting prisms that control the direction of the light are sealed from contact with the air. The hood and the holder for the outer globe are drilled for drainage so that any water that might collect by condensation or leakage will be taken care of. Both outer and inner surfaces of the refractor are smooth and easily cleaned when required. One unit per bay with 300-w. lamps is used, thereby reducing the initial cost and realizing the efficiency of the larger lamps.

There are four types of refractors, all made to fit the same metal holder. Each refractor has a distinct light distribution so that any condition may be taken care of without waste of light.

ASSISTANCE to investigations on the quality of iron blast furnace slags by Professor Richard S. McCaffery of the University of Wisconsin, sponsored by the Am. Inst. of Min. and Met. Engrs. and on dielectric absorption by Professor John B. Whitehead of Johns Hopkins University, sponsored by the Am. Inst. of Elec. Engrs., has been granted by the Engineering Foundation Board. The first would make possible the use of iron ores containing more sulphur than is now practicable, the second would help in overcoming electric losses and the depreciation of insulation in power generation and transmission.

THE PROPER treatment of feed water is one of the most important operating problems of any plant.

Classification of Automatic Station Devices

AUTOMATIC station devices may be classified as follows:

(1) Line circuit interrupting devices: Air circuit breakers, oil circuit breakers, direct-current contactors, alternating-current contactors.

(2) Mechanisms: Motor or solenoid mechanisms for operating air or oil circuit breakers, motor-driven brush-operating mechanisms for synchronous converters.

(3) Control and auxiliary contactors: Small alternating-current operated or direct-current operated contactors with from one to eight contact circuits.

(4) Relays: Overcurrent: Direct-current plunger types, alternating-current induction or plunger types, alternating-current — direct-current grounding protective relay; Sensitive alternating-current under-voltage relay; Hesitating drop-out relays; Sensitive voltage or current relays; Alternating-current differential relays; Direct-current directional relays; Thermal or temperature relays; Timers; Auxiliary: Plunger and hinged-armature type relays.

(5) Miscellaneous: Motor-driven master switches, float switches, time switches, pressure switches.

Protective features may be divided into two classes: (a) Those which merely shut the station down and allow it to restart again when the trouble has been cleared due to unusual conditions caused by trouble outside the station, and (b) Those which, in addition to shutting it down, lock it out, preventing it from being started again until someone visits the station. This class of protection is needed in case of serious trouble inside the substation which cannot be cleared automatically.

The protective features will operate:

To Prevent Starting the Station if: (a) the a.c. line voltage is below a safe operating value; (b) the a.c. power supply is single phase or reversed phase; (c) the station has been shut down temporarily due to overheating of the machine windings or the load limiting resistors; (d) the d.c. brushes are not raised from the commutator.

To Shut Down the Station Temporarily if: (a) the a.c. voltage is too low for safe operation of the station; (b) the machine is subjected to a moderate overload which continues until the windings overheat; (c) the machine is subject to an unbalanced phase condition which is considered dangerous; (d) a reverse current occurs equal to or greater than the normal light running current of the machine; (e) the load limiting resistors are overheated due to heavy overload.

Under each of the above conditions the station may start automatically as soon as proper conditions have been restored.

To Shut Down and Lock Out the Station If: (a) the equipment is subject to harmful overload or short circuit which may require inspection or repair before operating again; (b) the bearings should overheat; (c) there is an unbalanced phase due to some cause within the station; (d) the starting sequence should fail to be completed properly; (e) the machine should overspeed; (f) the machine should not be connected to the bus within a predetermined time.

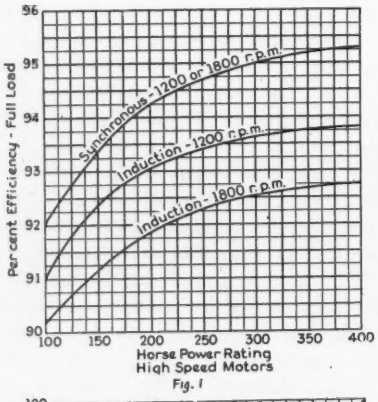
When locked out, the station will require manual attention to reset the lockout relay and inspect the machine before it can be restarted.

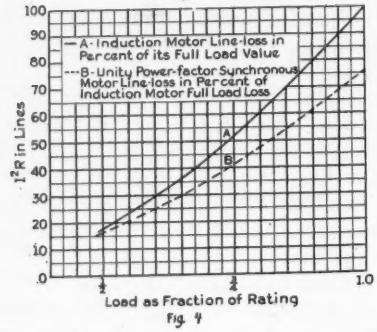
Choosing and Operating Ice Plant Motors

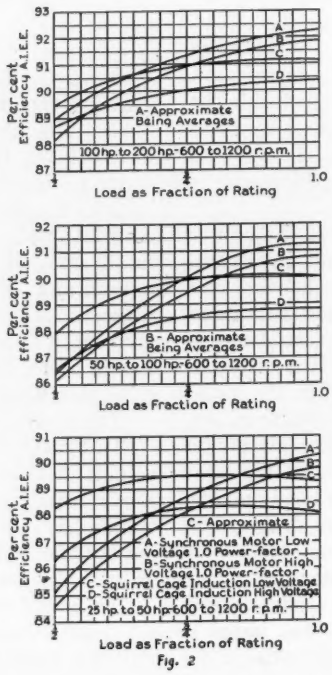
As Soon as the Chooser Asks Why One Motor Is Better for a Certain Job Than Another, Many Important Factors Are Revealed. By C. W. Cutler*

CHOICE OF AN electric motor for driving a reciprocating compressor or pump may be regarded in one of two ways. It may be merely the purchase of a motor (known to deliver sufficient power to drive the load) meeting with reluctance any restrictions placed upon the choice by outside sources, or it may be a real game in which the chooser will find a great deal of interest. If the motor be chosen merely as a machine to do the necessary driving, then more than likely the purchase is made upon being assured that it will drive the load. If, however, the chooser inquires as to why the motor in payable to the power company to cover the motor that is 1 per cent less efficient. In this case the story might be different.

Efficiency, however, is not the only consideration involved, for many other factors—torques, power factor, production results, effect on plant overhead, reliability and upkeep—reveal themselves when the subject is studied. The following discussion is presented, therefore, to assist in the choice of motors, particularly for driving reciprocating machinery such as ammonia compressors and pumps.


Percent Efficiency - Full Load
Synchronous - 1200 or 1800 r.p.m.
Induction - 1200 r.p.m.
Induction - 1800 r.p.m.
Horse Power Rating
High Speed Motors
Fig. 1


A - Induction Motor Line-loss in Percent of its Full Load Value
B - Unity Power-factor Synchronous Motor Line-loss in Percent of Induction Motor Full Load Loss
I²R in Lines
Load as Fraction of Rating
Fig. 4


Per cent Efficiency A.I.E.E.
A - Approximate Being Averages
100 hp. to 200 hp. - 600 to 1200 r.p.m.
50 hp. to 100 hp. - 600 to 1200 r.p.m.
25 hp. to 50 hp. - 600 to 1200 r.p.m.
C - Approximate
A - Synchronous Motor Low-Voltage 1.0 Power-factor
B - Synchronous Motor High-Voltage 1.0 Power-factor
C - Squirrel Cage Induction Low Voltage
D - Squirrel Cage Induction High Voltage
Load as Fraction of Rating
Fig. 2

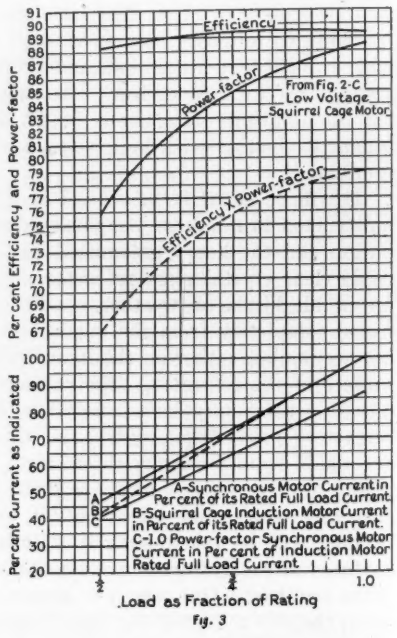

Percent Efficiency and Power-factor
Efficiency
Power-factor
From Fig. 2-C Low Voltage Squirrel Cage Motor
Efficiency X Power-factor
Percent Current as Indicated
A - Synchronous Motor Current in Percent of its Rated Full Load Current
B - Squirrel Cage Induction Motor Current in Percent of its Rated Full Load Current
C - 1.0 Power-factor Synchronous Motor Current in Per cent of Induction Motor Rated Full Load Current
Load as Fraction of Rating
Fig. 3

FIG. 1. EFFICIENCY COMPARISON CURVES OF HIGH-SPEED SYNCHRONOUS AND INDUCTION MOTORS. FIG. 2. EFFICIENCY COMPARISON CURVES FOR 40-DEG. MOTORS. FIG. 3. COMPARATIVE LINE CURRENTS OF THE TWO TYPES. FIG. 4. COMPARATIVE LINE LOSSES OF THE TWO TYPES

question is better fitted to the job than other available types of motors, then the choice will be seen in an entirely new light.

Often has the statement been made by the purchaser of a motor that he has no time to worry about 'such details,'' that he has decided to buy ''that type of motor'' even though it is 1 per cent less in efficiency for the duty cycle involved. The power loss because of lower efficiency is like paying for the extra power on the installment plan. This can be illustrated by assuming that the power bills are alike on both machines and that, instead of the increased monthly power bill of the less efficient motor, there is attached a note to the power contract providing that, at the end of ten years, a sum of $1000 (probably half the price of the motor) becomes due and

*Industrial Engineering Dept., General Electric Co.

The following divisions of the subject will be observed:

A, Motor Characteristics—(1) Efficiency curves of most common alternating-current motors, (2) Torque comparisons, (3) Reliability, space and maintenance comparisons, (4) Fundamental relative first costs; B, Operating for Economy.

Consideration of Efficiencies

High-speed motors (1200 and 1800 r.p.m.) are often used for belting to compressors, for gearing to reciprocating pumps or for direct connection to centrifugal pumps.

Figure 1 shows a comparison of approximate full load efficiencies of the synchronous and induction motors which are most fitted for these drives.

It might be assumed from Fig. 1 that the use of a synchronous motor of a certain rating instead of an induction motor would result in increased motor efficiency of operation. This curve shows only part of the story, however. Figure 2A represents motors of 600 and 1200 r.p.m. in ratings between 100 and 200 hp., showing how efficiency varies with load. Figure 2B represents machines between approximately 50 and 100 hp., while Fig. 2C represents motors between approximately 25 and 50 hp. The curves indicate that, considering efficiency only, the external load conditions might easily dictate the choice of one or the other of these two types of machine.

It is also interesting to note that, on large units, the synchronous motor is above the induction motor at most loads as shown in Fig. 2C. But, as the rating of the unit decreases, the point where the efficiency curves cross creeps nearer to full load, as shown by Fig. 2. The conclusion must inevitably be reached that, at least from the standpoint of efficiency, the use of a synchronous motor in ratings below 25 hp. is questionable, and below 20 hp. the induction motor stands alone.

From this viewpoint, for loads which remain constant at full value, the efficiency of a belted synchronous motor in ratings above 20 hp. is greater than that of the corresponding belted induction motor. As is well known, however, a slight margin in rating is often desirable and the motor may normally run at 80 per cent load for at least part of the year. This results in extending the range of usefulness of the induction motor up to nearly 50 hp.

Losses External to Motor; Line Losses

Motor efficiency is not the overall efficiency, however. and before deciding which motor seems more economical in operation, consideration should be given to the relative line losses back to the point of metering. Figure 3 shows the comparison of the per cent of full load current at various loads for the two types of motors. The comparative line losses are given in Fig. 4 for the two types of motors. This figure shows less line loss for the synchronous motor, as low as half load, even though the efficiency of this motor is less than that of the corresponding induction motor.

This difference in loss external to the motor would probably be small and could in general be neglected. In case transformers or long lines are used, however, the difference is worth considering and should at any rate be kept in mind when making efficiency comparisons.

To summarize, consideration of overall efficiency usually indicates that the belted synchronous motor is more acceptable for ice plant auxiliaries than the belted induction motor, for the sizes above 50 hp. But, between 20 and 50 hp., there are cases where the induction motor may be more acceptable.

Slow Speed Motors

For the main motor drive where the unit is comparatively large, considerations of space and elimination of belting along with other factors have directed the present-day application rapidly to direct-connected motors. Ease of installation, first cost, power factor and efficiency have given the slow-speed synchronous motor distinct advantages in the slow-speed class. The synchronous motor is so arranged that its rotor is mounted directly on the compressor shaft, either between the two cylinders, Fig. 5, or overhung on the compressor shaft, Fig. 6. Figure 7 shows another feature of the synchronous motor which makes it commercially more desirable than a direct-connected induction motor for reciprocating compressor drive. This figure shows the same motor used in Fig. 6 except that flywheel (ballast) rings have been bolted to the side of the rotor, thus supplying the necessary flywheel for the compressor operation.

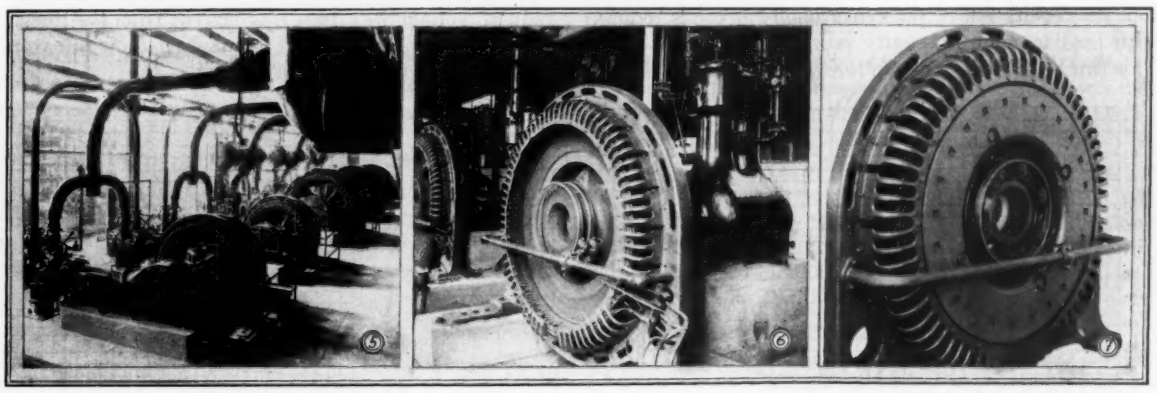


FIG. 5. SYNCHRONOUS MOTOR MOUNTED BETWEEN THE TWO CYLINDERS OF A COMPRESSOR. FIG. 6. MOTOR OVERHUNG ON COMPRESSOR SHAFT. FIG. 7. BOLTED BALLAST RINGS FURNISH FLYWHEEL EFFECT

Efficiency and Power Factor Comparisons of Slow-Speed Motors

Even though the external (physical) characteristics of the slow-speed synchronous motor give it advantage over the corresponding slow-speed induction motor, this advantage would mean little if first cost, efficiency, and power factor dictated otherwise. The efficiencies of slow-speed synchronous motors of the average sizes are shown (approximately only) on Fig. 8. From it can be deduced that, for any one speed of unit, the efficiency increases with the size of unit (useful when determining the sizes of plant). Further, it will be noted that, for any one size of motor, the efficiency increases as the synchronous speed increases.

Figure 8 was plotted on the basis of full load based upon the fact that the greater proportion of slow-speed motors for compressor drive operate at full load. On

ammonia compressors, however, the amount of load on the unit is dependent to some extent upon seasonal variations, so that, during the winter months, the driving motor would be likely to operate at fractional load. In air compressor service also, fractional capacity is often used. In both of these cases the full-load capacity is not the only consideration.

In the case of the slow-speed motor, however, the efficiency of the motor varies with load approximately as shown in Fig. 9. It will be seen that the curve is comparatively flat. A comparison of Fig. 9 with Fig. 2 shows that the slow-speed synchronous motor may be more efficient under variable load service than the belted synchronous motor. For certain sizes, however, this might be questionable, as intimated by comparison of Fig. 8 and Fig. 2. In fact, a careful study might often reveal that a belted synchronous motor would be economically preferable to a slow-speed, direct-connected unit. This can be determined only by taking specific examples and making comparisons as mentioned.

It should be noted that Fig. 9 is based on the assumption that excitation of the synchronous motor is reduced with load to maintain unity power factor at all loads. This can be done only where the variation in load is very slow, such as in seasonal variations, so that the operator may adjust the excitation to correspond to the load; however, for sudden variations, this is not practicable and a curve similar to the dotted line in Fig. 9 would apply, excitation being set at full load value and operation continued without further attention.

Slow-speed induction motors in ratings between 150 and 500 hp. have efficiencies of approximately the same values as synchronous motors at full load (that is, from 89 per cent in small sizes to 93 per cent in large sizes); however, the power factor of the slow-speed induction motor ranges from 60 per cent to 80 per cent (or an average of about 70 per cent) at full load. Since this is often the main motor of the plant, the power factor becomes the limiting feature. It should also be remembered that the initial cost is higher and there is greater difficulty in mounting on the compressor shaft.

It will be found in general that the starting torque of a synchronous motor is a function of rated speed. The high-speed synchronous motor is practically interchangeable in dimensions with the squirrel-cage induction motor of the same speed and horsepower rating. The starting torques are also approximately the same. The slow-speed synchronous motor has torques of a magnitude similar to the slow-speed squirrel cage induction motor. In general, therefore, there is little choice between the two types of motors from a torque standpoint.

Starting Currents

Although the starting torque of a slow-speed motor is low, the inrush current is also low when full voltage is applied to the motor, so that full voltage starting torque can be utilized (see Fig. 10). From this figure, however, it will be seen that, as the rated speed of the unit increases, the inrush current also increases. Although a high-speed motor would develop high starting torque when thrown on full voltage, the starting current is also high. Often, therefore, the inrush current is prohibitive and, in order to keep this down to an acceptable or reasonable value, the motor has to be started on reduced voltage with correspondingly reduced starting torque.

Nevertheless, the high-speed motor when started on reduced voltage will draw less current from the line than a corresponding slow-speed motor started on full voltage for equal torques delivered.

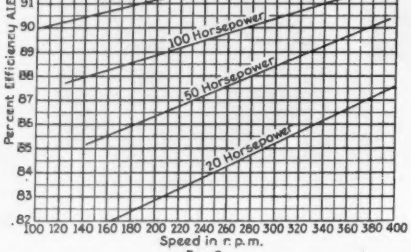


Fig. 8

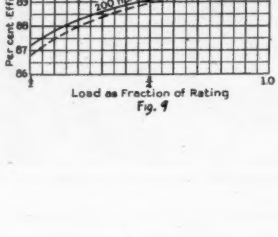


Fig. 9

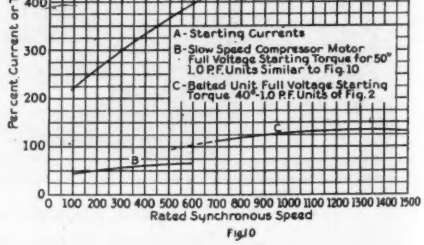

A - Starting Currents
B - Slow Speed Compressor Motor Full Voltage Starting Torque for 50° 1.0 P.F. Units Similar to Fig. 10
C - Belted Unit Full Voltage Starting Torque 40°-1.0 P.F. Units of Fig. 2
Per Cent Current or Torque
Rated Synchronous Speed
Fig. 10

FIG. 8. TYPICAL FULL LOAD EFFICIENCIES FOR SLOW-SPEED, 1.0-P.F. SYNCHRONOUS MOTORS. FIG. 9. PART LOAD EFFICIENCIES FOR THE SAME MOTORS. FIG. 10. TENDENCIES IN FULL VOLTAGE STARTING CURRENTS AND TORQUES FOR THESE MOTORS

Care should be exercised in the application of this difference, however, because when the motor is started on full voltage, there is only one inrush of current from the line whereas, when a motor is started on reduced voltage, it must be transferred to full voltage, thus causing two distinct inrushes of current from the line.

Reliability, Space and Maintenance

It has been felt that the synchronous motor was more complicated to start than the induction motor. This may have been true at one time, but improvements in the synchronous motor and its control equipments have been made rapidly in the last few years. Today, the synchronous motor and the induction motor are equally simple to handle. Figures 11 and 12 show the extreme simplicity and similarity of these two types of panels.

In comparisons of reliability, therefore, the problem is reduced to comparisons of the belted unit (reliability of the belting and extra bearings) with the direct-connected unit. Space requirements go hand-in-hand with the problem of belting.

In discussing first costs, the effect of the type of

motor on installation and erecting costs should be considered. This is, however, outside of the scope of the present discussion. All that can be given here are relative values for the electrical units exclusive of installation: These factors apply only roughly to the specific cases chosen. They are given so that an idea may be obtained as to the relation that exists between the various types.

Type of motor	Arrangements*	Relative costs with simplest possible control
Slow-speed induction.....	A	150—175%
Slow-speed synchronous....	A	100%
Belted synchronous.....	B	75— 85%
Belted, wound-rotor induction	B	65— 75%
Belted, squirrel-cage, induction	B	50— 60%

*"A" denotes an arrangement for mounting on compressor shaft.
"B" is equipped with base, shaft, bearings and pulley.

Only the equipment absolutely necessary to make the motors operative has been included. In the case of the slow-speed synchronous motor a motor-generator exciter is included and, in the case of the belted synchronous motor, a direct-connected exciter is included.

How to Operate for Economy

In the foregoing discussion it has been assumed that the problem was that of choosing the proper motor for the job. But, once having a motor, there is an additional responsibility for the operating engineer. Probably more money can be saved by the operating engineer than by anything which the designer of the plant can do to increase efficiency. The designer of the plant can do no more than to place in the hands of the operating engineer equipment and well-balanced "tools" fitted for the business of making ice. After this a big responsibility falls upon the man who uses this equipment.

Factors affecting efficiency which have just been discussed are a small proportion of the total plant losses. The efficiency of the remainder of the ice-making cycle must be given the greater study. However, there is a rapidly increasing number of operating engineers who take a real pride in operating their plants at highest efficiency. After having studied the refrigeration cycle, therefore, the discussions of motor characteristics just given may allow slight modification of operation more

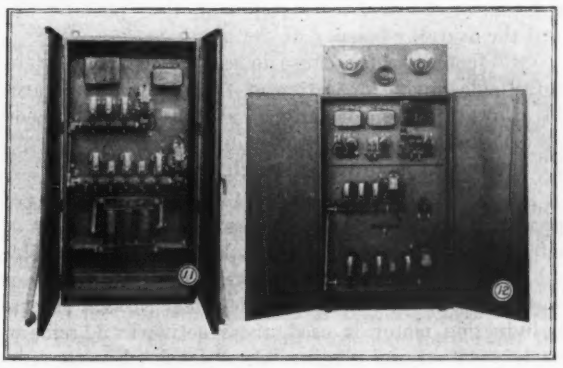


FIG. 11. ENCLOSED AUTOMATIC STARTER FOR SQUIRREL CAGE INDUCTION MOTOR. FIG. 12. ENCLOSED AUTOMATIC STARTER FOR SYNCHRONOUS MOTOR

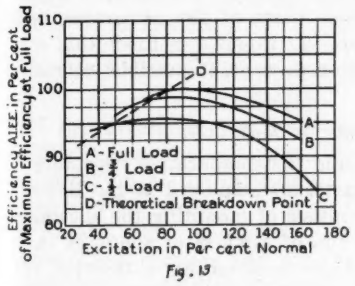

Efficiency A.I.E.E. in Per cent of Maximum Efficiency at Full Load
Excitation in Per cent Normal
A - Full Load
B - ¾ Load
C - ½ Load
D - Theoretical Breakdown Point

Fig. 13

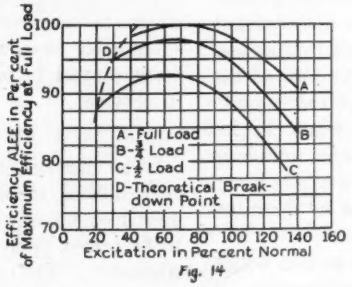

Efficiency A.I.E.E. in Per cent of Maximum Efficiency at Full Load
Excitation in Per cent Normal
A - Full Load
B - ¾ Load
C - ½ Load
D - Theoretical Breakdown Point

Fig. 14

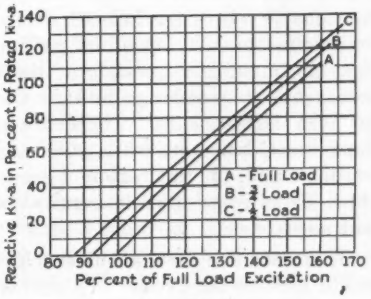


Fig. 15

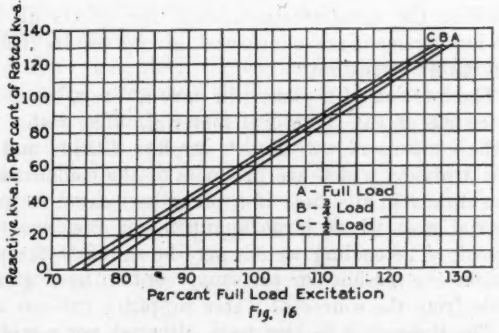


Fig. 16

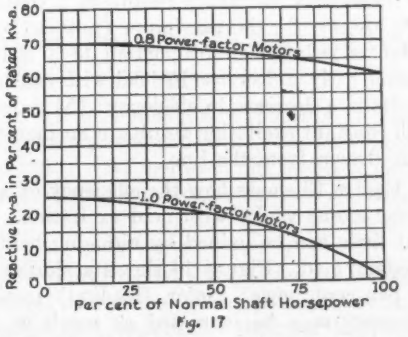


Fig. 17

FIG. 13. VARIATION OF EFFICIENCY WITH EXCITATION 1.0 P.F. 40-DEG., 25 TO 75-HP., MOTORS. FIG. 14. VARIATION OF EFFICIENCY WITH EXCITATION FOR SAME MOTOR WOUND FOR 0.8 P.F. FIG. 15. CHANGE IN REACTIVE KV.A. WITH EXCITATION FOR THESE MOTORS (PROVIDED FIELDS WILL NOT BE INJURED BY OVER-EXCITATION). FIG. 16. VARIATION OF REACTIVE KV.A. FOR 0.8 P.F. MOTORS OF ABOVE CHARACTERISTICS. FIG. 17. VARIATION OF REACTIVE KV.A. WITH REDUCTION IN LOAD AT CONSTANT FULL LOAD FIELD EXCITATION

favorable to the electrical equipment, thus pushing upward the overall efficiency of the plant.

Two factors which cause losses are to some extent controllable during operation of the plant. These are: (1) kilowatt losses normally incidental to transmission and conversion of electric power into mechanical energy; (2) reactive kv.a. drawn through the system.

The most that can be expected with any one group of apparatus is that the kilowatt loss between the point of metering and the driven shaft be kept as low as possible and that the reactive kv.a. be kept as near zero as is consistent without handicap under item No. 1. In case an induction motor is used, the reactive kv.a. remains nearly constant and lagging for all loads while the kilowatt losses vary as the motor load is changed.

Since the losses are so closely tied up with the production results, the conclusion may easily be reached that adjustments in operation cannot be made except by one method. The rule is to keep each induction motor operating well up on its load curve by taking off the line other equipments which are not actually needed. Or restating, it follows from previous curves shown that, if the load drops off materially, the unit should be shut down if possible, transferring the little remaining load to some unit already operating or to a smaller unit which can be started up for this purpose. By following this general rule, a saving of as much as 2 per cent might be expected, as is shown by Fig. 2. In addition to this, the power factor of the induction motor will be improved. This will result in lower losses in the motor leads and often a lower power bill.

With a synchronous motor, however, there is an added flexibility available: that of adjustment of excitation by field rheostat control. This adjustment is often questionable where the benefits derived do not warrant the amount of time spent in making the adjustments. This, of course, is a question of the relative size of the motor, rate of load change and the time required in making such adjustments. There are many times in ice plant work, however, when such adjustment would be profitable and, for this reason, a group of curves is given which shows in general the results obtained by field and load adjustment.

There are five facts about synchronous motors which should here be observed: (1) decreased excitation on a synchronous motor results in less leading reactive kv.a.; (2) decreased excitation results in a reduction of kilowatt losses; (3) the maximum (pull-out) torque of the motor is reduced in proportion to a reduction in excitation; (4) a decrease in load with constant excitation results in a decrease in efficiency; (5) a decrease in load with constant excitation results in an increase in reactive kv.a. drawn from the line.

Figure 13 shows how the efficiency of a unity-power-factor motor varies with field excitation. It is evident that little can be gained by reducing field excitation at constant load. Figure 14 shows a similar curve for an 80 per cent power factor (leading) motor. Here the efficiency may be increased as much as 3½ per cent under some conditions. This can be utilized provided the reactive kv.a., is not needed to assist in power factor improvement of the remainder of the plant. Such a condition might arise when, at certain times, the remainder of the plant being partially shut down or the power factor improved, the extra leading reactive kv.a. is not required and this saving could be effected.

Figure 15 shows how the leading reactive kv.a. might be expected to vary with excitation and load for a unity-power-factor motor.

Figure 16 shows how the leading reactive kv.a. might be expected to vary for an 80 per cent power-factor motor.

Figure 17 shows a set of average curves for reactive kv.a. plotted against load with constant excitation applied.

These curves are intended as operating guides which show tendencies and should assist materially in determining how to adjust and operate the synchronous motor under any specific set of conditions. Since the ice plant, cold storage, or ice cream plant loads are more or less cyclic in nature and the changes are relatively slow, a little thought along this line might be justified.

Corrosion in Refrigerating Systems*

By N. B. Ornitz†

ALTHOUGH it is by the complete understanding of the mechanism of the corrosion of iron and steel that methods of protection and prevention can be devised, it is not the purpose of the present paper to compare the virtues of the various theories, but to call attention to the possible application of results to the specific problem of preventing or retarding corrosion in refrigerating systems.

The problem resolves itself into two phases: (1) Choice of the structural material or materials from which to construct those parts of the apparatus most susceptible to corrosion; (2) Possible methods that may be employed to retard or prevent, if possible, corrosion in service.

Choice of Material

The method of testing the comparative resistance to corrosion of various materials employed at the Babcock & Wilcox laboratory consists of mounting the specimens to be tested upon the rim of a wheel of about 24 in. in diameter. The wheel is revolved at a definite rate through the corrosive medium, which may be either liquid or gaseous. In this way each specimen is subjected to the same treatment and the effects of lanes and impingement are eliminated, giving results that are remarkably consistent.

The location of a plant will have a direct bearing on the choice of the structural material. The water used in the condensers will absorb sulphur dioxide and sulphur trioxide, which are products of the combustion of the sulphur in the fuel, if a plant be located in an industrial area where large quantities of fuel are being burned. The cooling waters may be saline if the plant be near the seashore or they may contain hydrogen sulphide from the source of water supply.

The Babcock & Wilcox tests, although not completed, indicate that wrought iron as made today corrodes slightly more rapidly than steel when subjected to the

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†Metallurgical Engineer, The Babcock & Wilcox Tube Co., Beaver Falls, Pa.

corrosive action of aerated water, with or without saline salts in solution. This type of corrosion is withstood remarkably well by stainless iron, although this material is not actually "stainless," there being a decided discoloration and a tendency to pit in saline salt solution. The rate of corrosion, however, is approximately 1/100 of that of steel. Copper bearing steel is approximately 20 per cent better than wrought iron or steel in water containing sulphurous and sulphuric acids, but offers no advantages in an aerated water containing saline salts. Seamless tubes made from copper bearing steel are obtainable and at least one manufacturer has succeeded in fabricating commercially seamless pipe made of stainless iron.

Heyn and Bauer, and later Friend, noticed that the rate of corrosion of iron and steel in moving water increased with the increase in velocity up to a maximum at approximately one-quarter mile an hour and then decreased to a minimum at approximately two miles an hour. But in the case of an acid solution the rate of corrosion increases with increase of velocity and is directly proportional to it. The character of the water and its velocity will have a great bearing on the corrosion problem.

Water lines, which are exposed to low temperatures, and in which therefore the water is likely to freeze, should be made of seamless steel. Tests show that butt welded pipe in all sizes up to 2 in. will burst upon the first freezing of the water in the line. Seamless pipe of the same sizes can be successively frozen a minimum of four times without bursting the pipe. In testing 2½-in. lap welded pipe, 50 per cent burst upon the first freezing of the water and the remainder burst upon the second freezing. Seamless pipe in the same size withstood from three to seven freezings.

Methods of Retarding or Preventing Corrosion in Service

If two dissimilar metals are partly immersed in an electrolyte connected externally by a conductor, a current is set up at the expense of the metal having the higher solution pressure (that is, the more electro-positive metal), which goes into solution. Iron and steel, because of impurities and segregation, behave as dissimilar metals in adjacent areas, and when in contact with an electrolyte the material having a higher potential dissolves preferentially to that of the lower potential, causing pitting.

For this reason steel, for service in refrigerating systems, is being protected with metals that are electro-positive to iron, and in such cases they are slowly eaten away. When this protection has gone the iron and steel corrode as if they have had no previous protection. It but delays, and sometimes accelerates, the final failure.

Iron oxide, as mill scale, when in the form of a continuous unbroken coating, will protect steel, but once the coating is broken, the corrosion will be accelerated with a decided pitting.

Attempts are at present being made to coat seamless steel pipes continuously with an enamel which is highly resistant to corrosion. The first experiments of the Babcock & Wilcox have just been completed and it is hoped to put some of these pipes out for test soon. This company is also coating steel with aluminum by a dip process. This type of protection may be of some value in the corrosion field.

It has long been known that iron will not rust in dry air, nor will it corrode in pure water if oxygen is completely excluded. As a result, there are being manufactured deaerators and deactivators for removing oxygen from the water.

Friend has shown that the concentration of a saline salt solution has a marked effect on corrosion. As the concentration of the salt increases, from zero, the rate of corrosion increases to a maximum and then decreases. When a certain concentration is reached corrosion entirely ceases. This point, however, may lie beyond the saturation point of the salt, in which case the complete prevention of corrosion is never affected. As far back as 1845, Adie proved that a concentrated solution of sodium chloride was less corrosive than distilled water, whereas dilute solutions of sodium chloride are extremely corrosive. Though the increase in concentration of neutral salts has been known to decrease the solubility of oxygen, there are many other salts where the decrease in the rate of corrosion is far greater than the decrease in oxygen solubility.

By increasing the concentration of the calcium chloride brine solution the rate of corrosion in brine lines will be decreased. The freezing point of the calcium chloride brine solution is lowered with increase in concentration, up to approximately 29.8 per cent, which is the eutectic, the solution having a freezing point of —55 deg. F. at this concentration. But as the concentration is increased from this point the calcium chloride precipitates from the solution at higher temperatures, so that with a concentration of 33 per cent calcium chloride the freezing point is 4 deg. F. and with a concentration of 36 per cent the freezing point is approximately 32 deg. F. This limits the degree of concentration that may be used for the cooling brine. It may be possible that a double salt solution, having a low freezing point with a concentration that will give no corrosion, may sometime be developed for the cooling system.

Regardless of whether or not one believes in Friend's colloid theory, the facts remain that chromates and bichromates will retard corrosion with the least concentration, while the chlorides and nitrates require the maximum concentration.

Critical Speeds of Shafts and Heavy Rotors

In the above article, published in the July 15 issue, the sentence beginning at the end of line 21, 1st column, page 785 should read: "If, however, the model is given a refined balance, it will *not* become excessively rough, etc."

According to a report recently issued by the Department of Commerce the value of manufactured fuel, including briquettes and boulets, for the year 1925 was $5,892,030, which is an increase of 5.5 per cent over that in 1923, the last preceding census year. Of the 13 establishments reporting, three were located in Pennsylvania, two in California, two in Virginia, two in Wisconsin, and four in other States.

Prepare for a Siege

DON'T LET WINTER CATCH YOU UNPREPARED. BY C. C. HERMANN

EVERY POWER plant engineer holding a job north of the Mason and Dixon Line should take a trip afield during these fall days. There he will come upon the greatest practical lesson of his career. The title of that lesson is "Preparing for a Siege." It is more than a lesson to those who will take the trouble to observe; it is a veritable theater. The stage is set and decorated by the greatest of stage artists, Nature; the actors, the least self-conscious of any that could take their place on a stage for they are the insects, the animals and fowl of the field, forest and stream.

There was never a busier army of workers than these. Nor was there ever an army of workers supplied with more complete plans than these. Even Nature takes a hand in the preparations by providing the workers with a suit adaptable to the climatic conditions which will presently besiege them. Every hair, every extra layer of skin, every feather, every bit of down, every bit of fur added to the summer coat has a function to perform during the siege. Every acorn, every nut, every bit of food stored away has been carefully weighed and with an accuracy almost uncanny they store just sufficient to break the siege. When the days of spring come once more and the sun has eliminated the frigid angle of its rays, when the surface of mother earth is once more free of the desolate clutches of ice and snow, there is not one acorn or nut or other matter fit to eat left in the hollow tree. So closely do they bank their stores, so thoroughly do they prepare for the siege.

Having viewed these workings of natural forces, having observed how like clockwork the preparations proceed, we must acknowledge our own shortcoming. We bow our head in reverence and wend our silent way back to the old power plant, feeling that with all our educational facilities, we have learned a lesson today far surpassing anything we had heretofore experienced. Perchance we ourselves have filled a pocket or two of the choice fruit of the tree and mayhap we even came across a tardy bloom which now adorns a button-hole on a heaving chest. Certainly we have filled our mind with a bit of God's wisdom and our soul has been touched by the tinge of color on every hand.

We, too, have a siege before us and for that siege we must now prepare, for it is timely. The first step is the procurement of a plan. Without a plan Nature might have mixed things up dreadfully out there in the forest. Without a plan many power plants will be found badly muddled up this coming winter. The coal will go into the furnace at the usual high rate and the steam will go sizzling into the hot well through blowing traps.

First a plan must be evolved, but a plan may mean almost anything. We must construct our plan carefully, perhaps something like this: 1st. The producing units. 2d. The consuming units. 3d. The radiating units. 4th. The return equipment.

The producing units are the steam generators or boilers. Perhaps some of them were placed in reserve last spring and we must now prepare them for action. Was the boiler properly cleaned last spring? It is well to look things over and see that all the old scale, soot and refuse has been removed from the boiler and setting. If this has not been done there is no more opportune time than the present for doing it. The setting no doubt has absorbed some moisture and requires drying out just like a new setting. It would be a good time to inspect the combustion chamber walls and grate and make the necessary repairs. The wise engineer will sacrifice just a little wear in this connection in order to insure continuous operation through the siege; however, this is a matter for superior judgment since fire brick are expensive.

Are there any leaky tubes? Perhaps that old note book would be of some assistance. Many things were jotted down on the sheets of the note book and then forgotten or allowed to drag along until some more opportune time would present itself. Now is the time to get right into the heart of these matters; and while we're about it they may as well all be looked over. The removal of the scale will give us a good chance to inspect the tubes. Perhaps a slight re-rolling here and there is all that is needed.

Then there is that non-return valve which gave us some trouble last year. It is well to clean it out and see that it is in good working order before starting up. The blowoff too leaked just slightly and perhaps needs some attention.

The purchasing agent promised us some additional pipe and steam dome covering and this is a good time to remind him that this material has not arrived. The boiler room will be warm enough without the radiation from the boiler drum and steam header so we might as well make a saving by properly insulating them.

Don't forget the breeching and stack. The damper needs some repairs. A repair of this nature is extremely important. Unless the damper is in good shape the boilers will be operated from the ash-pit door and we know that such practice cuts down the efficiency remarkably. On the other hand, if this is the only method there is for control then the setting should be inspected carefully for leaks. Infiltration of air through the setting will result in a considerable drop in economy which can be avoided. Paint is a mighty good thing for breeching and stack. It doesn't hurt the stack guy wires either. While the painting is going on the breeching and stack should be inspected for leaks and rusted out places.

Sweep the cobwebs away from the pit to the boiler feed pump. The old pump hasn't been overhauled since the war and we fear it won't go through the winter without some trouble. But when we get it opened up we are surprised that with a few repairs it is going to last another year and perhaps another after that. This is the time to economize. With the business horizon looking pink, we feel that every effort should be made to show a nice profit on the year's business and help the general industrial condition. It certainly is not a time for extravagant expenditures. On the other hand, good judgment must be exercised so that in our enthusiasm we do not plug a little spigot hole in one end of the barrel when the entire head is out the other.

Perhaps the plant uses the power-generating units only during the heating season and the exhaust is turned into the mains for heating purposes. If this is the condition it will pay to build a fire under the old tea-kettles and turn the prime-movers over a few times. Give them a good limbering-up and don't forget to grease all the joints. Perhaps the old grease has hardened and should be cleaned off. A steam engine used only during the heating season doesn't require an overhauling every year but, if too many years are allowed to slip by, serious trouble will develop one of these days. It is well to take a good look around at this time.

How about trapping the condensate from the steam header and how about that steam separator just ahead of the cylinder? Is the water glass in shape or is it like a good many others, broken and forgotten? The efficiency of the steam engine increases with the dryness of the steam that ultimately enters the cylinder. Did you ever consider the advantages of a drop leg at the end of the steam engine header to take care of the header condensate? It is a big help at times and if the boiler feed steam line is taken off of this drop leg it insures the removal of all condensate; however, it is best to place a trap at the end of the leg and not ask the pump to handle water in both cylinders.

Radiating elements always provide plenty of work for the pipefitting gang. Here again the old notes can be consulted with advantage. Perhaps that bank of coils down in the forge shop or over in the assembling department has not been repaired following that last freeze-up. The radiator will be absolutely useless until it is repaired. A cold snap will come along one of these days and then someone is going to make it uncomfortable for the power plant boss. The little note book is just full of notes. Over here is a radiator supplied with a lead too small for the radiator, consequently the radiator is running cold 50 per cent of the time; or here is another which is robbed by another radiator. The fellows who work around these places maintain a production about 50 per cent lower than it should be just because some steamfitter pulled a boner on the installation.

In order to keep the radiators hot, the water must be removed; that is the function of traps; in many plants, however, the traps not only remove the water, but the steam as well. A bit of scale lodged beneath the diaphragm or a defective diaphragm drains all the steam out into the return, where the heat of the steam is dissipated in heating the water in the hot well and radiated to waste.

Is all the condensate returned to the boiler room? Is the make-up water injected direct into the boiler, into a hot well or into a feed-water heater? It makes all the difference in economy in the world which way these things are handled. To dump tons of water into the drain from the radiators is an unpardonable waste. The hot well is better than nothing, but a feed-water heater certainly pays for itself in short order.

APPLICATION has been made for a permit for the construction of a water-power project on the Nollichucky River in Tennessee to have a capacity of 70,000 hp. The application was filed by the Tennessee Eastern Electric Co., of Johnson City, Tenn.

Bureau of Mines Studies Mercury Production

BECAUSE OF THE RECENT development of the mercury boiler and turbine and the favorable reports of progress that have been issued on them, many engineers have wondered whether or not, if the use of the mercury turbine becomes wide-spread, the available supplies of mercury would be sufficient to supply the demand without causing a rise in price of mercury that would make the process prohibitive from a financial standpoint. That there is no danger of such a situation has been the feeling of those working with the turbine. Now we find the same feeling expressed in a report on the Metallurgy of Quicksilver by L. H. Duschak and C. N. Schuette, issued as Bulletin 222 by the Bureau of Mines, Department of the Interior.

In the years 1850 to 1923, the bulletin states, the United States produced 2,426,000 flasks (73,600 metric tons) of quicksilver, worth $120,500,000. California yielded 2,195,000 flasks of this total; the remainder came from Texas, Oregon, Nevada and Arizona. Most of this metal has been extracted from low-grade ores, those containing less than 0.5 per cent mercury or 10 lb. per ton. The finished product or "virgin metal" is made at the mine and shipped in flasks.

Quicksilver is the only metal that is liquid at ordinary temperatures. Because of this and other physical and chemical properties, it is perhaps more indispensable to industry than any other metal. On the other hand, the quicksilver industry of the world is of vanishing significance when compared to the major mineral industries with respect to quantity and value of product, capital invested, or the number of men employed. Of course, if the new mercury boiler and turbine should prove as successful as their sponsors believe, it will cause an increased demand for quicksilver but this demand is not likely to be great in the immediate future.

The unique relation of mercury to national health and security and the indispensability of the metal and its compounds in science and industry seem to justify investigation of the quicksilver industry by the Bureau of Mines. In Europe, government interest has been direct. In the United States, however, the quicksilver deposits which can supply domestic needs for many years to come are of course privately owned; and the industry has so far received little, if any, assistance from the Federal Government, except in the matter of tariff protection.

An opportunity to be of assistance was offered the Bureau of Mines in 1917, when certain quicksilver operators requested the aid of the bureau in making a study of quicksilver condensers, with particular reference to eliminating sources of loss that might exist in the treatment of low-grade ores. The matter was investigated by the Bureau jointly with several operating companies in California and the results have been published.

Bulletin No. 222 is devoted mostly to a discussion of the treatment of quicksilver ores, describing methods and equipment used in this country and abroad. The bulletin concludes with a discussion of the health hazard in the extraction of quicksilver and a bibliography on quicksilver metallurgy.

Cheap at Half the Price

By John S. Carpenter

"THERE'S ALWAYS some guy connected with the workings of a water power plant who makes this business what it is instead of what it should be!" declared William W. Williams, our otherwise genial and heavybuilt chief. He packed a bunch of letters and catalogs into a large envelope and started for the office of the General Purchasing Agent, where he evidently expected no joyous session.

"Hello Bill!" snapped the P. A., "can't see you today, I'm too busy!" He went right on fumbling over a pile of letters.

"The dickens you are! You're gonna listen to me right now and talk like a gentleman or I'll throw you and your crew into the river. Anybody who doubts my ability to make good, let 'em start me off!" From the ensuing silence you would have thought that the roof lifted a trifle and then hovering a moment, came right back where it belonged.

"What is it you want, anyhow?" the P. A. grumbled. "You always want to spend the company's money and if we let you have your way, we'd go b——."

At this point Bill grabbed the P. A. by the back of the neck and said in apology, "Pardon me, look at this pink sheet from the G. M. reading 'IMMEDIATE ATTENTION' and read them few short sentences!" Bill released the P. A. and smoothed his mussed hair.

"So Number Two oil pump has given out and you want a new one? Can't it be repaired?" A good P. A. never buys anything if he can get out of it.

"No. She's down and out. Worn out from use. She won't hold pressure and the valve chest is gone. The other pump isn't so much better so we better get one on order right away. This Star pump here," and Bill showed him a cut of a heavy duty pump, "is what I want, they have two down at the Union Plant and they sure are fine. The price is ——" and Bill showed him the quotation.

"Gosh" exclaimed the P. A., "that's an awful pile of money! How much are you getting out of it?" The P. A.'s smile was too sarcastic to be nice.

"Say that again," Bill cautioned, "and all you'll need is a shovel for your future occupation. You'll also need a good lawyer to get past St. Peter!"

"No, Bill, we'll get bids for you and I'll see if I can get a good used pump somewhere that'll do the trick. I betcha I can!"

"See here," Bill warned, "this stuff has to stay on the job, we can't take a risk on somebody else's trouble. Get us a new pump and if it's not right we have a comeback. Don't be always sorting over a junk pile."

"Beg your pardon, Mr. Williams, this is the Purchasing Dept. and you will please not dictate to us." The P. A. lighted another Elephant while the fray was going on heavy and assumed an imperial posture.

"Then go to blazes and buy your junk—I'll bet you'll buy twice, and a box of Coronas on that!" The chief's eyes meant business.

"I'll take that bet," snapped the P. A. and made a memo of it.

Bill then gave the P. A. some routine orders for regular supplies and departed with a general malediction on the P. A., junk dealers and all those who try to get something good for nothing. He paused a moment in the hall and turned back.

Holding open the P. A.'s door, he said in a voice that all could hear if 99.44 per cent deaf, "Say, I'm going away on two weeks' vacation tomorrow so get on the job and do something."

"Thank Goodness!" sighed the chorus, with relief.

Now Bill is not a half bad chap. When he wants anything, he has good reasons for wanting it and his judgment is good. The P. A. could not see beyond the present. Bill saw visions of future trouble with a lame duck that somebody ditched and probably for good reasons.

True to his word, the P. A. shopped around until he had a good used triplex that according to its rated figures was ample to handle the capacity and pressure. He also got a local machine shop to build a bedplate so he could mount the motor to drive it, in the right position to make a good chain drive.

While Bill fished and swam in the country with his family, the P. A. worked hard to get the new pump delivered and set up before the chief got back. This pump was large enough to handle the whole governor system load should the other old one go bad at any time. The P. A. and his staff were joyous that they had put it over Bill for once and the box of Coronas was to be divided among them. Even the G. M. was not averse to saving some money for the company if it could be done and get away with it, so he allowed the thing to go through and gave all the aid he could to expediting the work. There was some ill-advised gossip too, that the fat price for a new pump might have included a confidential commission for the party who vigorously insisted on a new pump. No, they admitted, they never "found anything" on Bill, still you never can tell!

When Bill came back all bronzed and bubbling over with pep, he found the new pump had been put in and was running. He had not had time to give it the once over, as the other hydro plant of the company had a thrust bearing go out and Bill was detailed by the G. M. to take that job in hand personally and get the unit on the line again. That took up his time for another three days and it was not until the fourth day that Bill felt he could get away. Without a doubt, Bill thought, the P. A. had won the cigars. He was distinctly peeved.

As he left the plant with his satchel of tools, a small truck drew up. "Get in chief," said the driver, "you're wanted down at the super's office at once. They just shut down the plant."

"What's the trouble down there? I just got through here and now they're down!" The chief went over the list of weaknesses in his mind and wondered which it could be.

The driver did not know what was wrong. All he did was make that truck go like greased lightning over the hills until they drew up at the main office with a final screech of brakes, so that the chief nearly went through the wind shield. "The next time I ride with you," he remarked "you'll ride alone! You're too good with that brake!"

Bill went right to the super's office. In the hallway, somebody came up behind and slapped him on the back. "Any time now, chief, that you can raise the money—I'll take that box of Coronas!" The P. A. greeted him with a triumphant heehaw.

"All right! As soon as I can get them." Bill disappeared into the super's office. There was the super, the G. M. and the Master Mechanic.

"Say Bill," began the super, "why didn't you tell that Purchasing Department that the new pump was to handle oil?"

"Please send a boy up there to get my correspondence, you'll find that I specified metal valves, the pressure and everything. I even gave them a sample bottle of oil. What did they buy?"

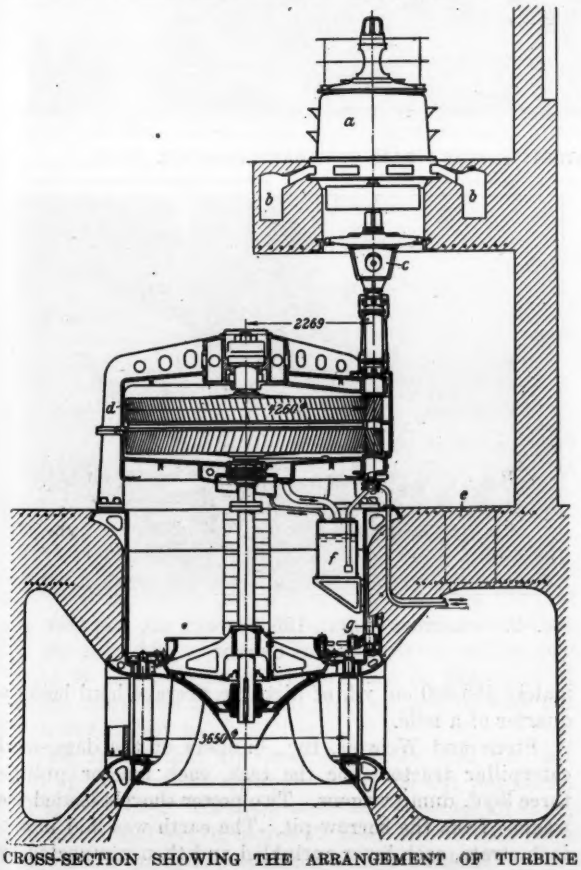
"Well it's a good Star pump all right, but it had rubber valves until the oil rotted them out this morning and the governor valves got clogged up with the mess. The governor started doing a highland fling shortly before the pressure failed."

"Too bad!" sympathized Bill, "you better get Mac to turn up some quarter inch boiler plate for a makeshift set of valves until we can get some repairs; and dump all the oil in the system and fill up with new stock after you clean the valves out." Mac started out.

"All right, Bill, you and Mac work together and let's see what you can do. The next time we buy any pumps Bill's gonna have his way. Purchasing Department be blowed!" The super said some nice words and manfully took the blame himself.

Geared Hydro-Electric Turbines

WHEN DRIVING electric generators by water wheels, it is generally recognized that the low speeds at which generators must run when direct-connected to turbine shafts cause an appreciable loss in efficiency of the unit. Generators operating at 1000 to 500 r.p.m. have from 2 to 4 per cent higher efficiency than those operating at speeds of 250 to 68 r.p.m. corresponding to average water wheel speeds. Generators for the higher speeds are usually cheaper with better electrical characteristics. On the other hand, water wheels with fixed blades are not always practicable. If, then, a slow speed water wheel can be arranged to drive a high-speed generator, the best results should be obtained.



CROSS-SECTION SHOWING THE ARRANGEMENT OF TURBINE GENERATOR AND GEARING OF GERMAN DESIGN

This has been attempted by the use of gearing between water wheel and generator and it is believed that the gearing loss is more than balanced by the gain in electrical efficiency. Small gear transmission ratios have been used with Francis type turbines. Gear ratios of 1:5 have been increased to 1:7 by the use of all-steel cogs and through the efforts of German engineers ratios of 1:15 and above have been developed and are being adapted, says the V.D.I.-Zeitschrift.

Unlike the bevel drive turbines, the drive, weights and strains of this arrangement exert no strain on the turbine housing. The drive is incorporated on the turbine itself while the generator stands on a special floor. Actual efficiencies of 99 per cent have been reported, one-quarter of the loss being attributed to the oil pump which maintains pressure lubrication. Considering all points, the steel-built, average speed geared turbine of this type will probably occupy an important position in low-head hydro-electric developments of the future.

Power Possibilities of the Tennessee Basin

PARTIAL report has been made by the Army Engineers, on the progress of their survey of the Tennessee River and its tributaries, involving an area in Tennessee, North Carolina, Alabama, and Kentucky.

After securing maps and stream-flow data for the Clinch, Powell and the Tennessee Rivers, the engineers promptly decided that the development of these streams would best be served by a system of 13 new dams. Five of these would be on the Clinch River, one on the Powell, five on the Tennessee, between Knoxville and Chattanooga, one between Muscle Shoals and Chattanooga, near Guntersville, Alabama, and one near Riverton, below Colbert Shoals. It is expected that with these structures there will be a 9-ft. depth for navigation from Riverton to Knoxville on the Tennessee and from the Junction of the Tennessee and Clinch Rivers, up the Clinch, to the towns of Clinton and Coles Peak, a distance of about 75 mi.; also, from the junction of the Clinch and Emory Rivers, up the latter to the town of Harriman.

From the nature of the territory, one of the dams on the Powell River and the two uppermost on the Clinch, would create large storage capacity, and permit large power development. The lower three on the Clinch River would provide for navigation and for some power, the amount depending on the water discharged from the storage dam above, while the seven dams on the Tennessee would provide for both power and navigation. It is expected that, by means of the storage dam, the minimum low water power available at the Wilson Dam No. 3, and the Interstate Dam below Riverton can be doubled while that at Hales Bar and at parts higher up, yet below the mouth of the Clinch River,

can be more than doubled. Water in the Clinch River basin can be held back when there is excess flow from the Tennessee, thus avoiding the waste of water during maximum flow.

Private companies have been interested in the development of power in this region and, before the Fall of 1925, applications were filed with the Federal Power Commission for twelve of these thirteen dikes with the thirteenth now being considered by a local power company. The studies of the survey indicate that the total power from these thirteen installations should be a million and a quarter horsepower and cost should not be in excess of $150 per horsepower, with navigation figures included. This is assuming that the thirteen dikes are developed as a single project but, if taken as separate projects, it is possible that one and possibly others could not stand on their individual merits.

Surveys have been extended to the tributary streams of the Tennessee, above Muscle Shoals but the matter has yet not gone far enough to warrant a report.

Two storage reservoirs, one on the Clinch and the other on the Powell River, will have a combined capacity of between 700,000 and 800,000 acre feet, with combined power capacity of about 120,000 hp. With these two and the Cove Creek reservoir operating, excess flood waters can be held over for several months, until the drought period and, in some measure, it might be possible to hold water from a wet year or period of years to a dry year.

Another storage feature possible, would be four dams, one on the Hiwassee River, below the mouth of Tusquitee Creek, another about 18 mi. farther down, known as the Murphy Site, another some distance below the town of Murphy, known as the Coleman Site, and a fourth at the North Carolina Tennessee State line, known as the Apalachia Site. These four dams, with possibly a fifth would give a total storage capacity of about 850,000 acre feet and below them the territory is such that power dams and installations can be built at almost any point desired. Private interests have been active in power development on the Hiwassee River to the extent of making plans, acquiring property and storage rights, and carrying on some litigation, but no construction has as yet been started.

On the Little Tennessee River, the Aluminum Co. of America has already started construction and has complete plans for its development, so that the Army Engineers have not considered this section.

It is expected that a favorable place for a dam can be found on the Big Pigeon River, below the mouth of Jonathan Creek, which will give available storage capacity of 250,000 acre feet, and a head of some 320 ft. at the dam. One declaration of development has already been filed with the Federal Power Commission for Big Pigeon River and other locations are possible but have not as yet been selected by the Army Engineers.

On the French Broad River there is favorable location for a dam about 3 mi. above Ashville, which would give a head of 130 ft. Below this dam there is a fall of some 1200 ft. in reaching the Tennessee River but plans have not been made for the utilization of this head as yet. The reservoir thus created would have a storage capacity of 1,000,000 acre feet and would add about 1400 cu. ft. a second to the minimum low water flow at the power plants below, including the No. 3 Wilson Dam.

Bartlett's Ferry Dam

BARTLETT'S FERRY dam of the Columbus (Georgia) Light & Power Co. is an example of the concrete type of dam supplemented by earth-fill wings. This dam in the Chattahoochee River, which forms part of the boundary line between Alabama and Georgia, is 125 ft. high and over a quarter of a mile long. The construction of the wings involved the moving of approximately 185,000 cu. yd. of dirt, the average haul being a quarter of a mile.

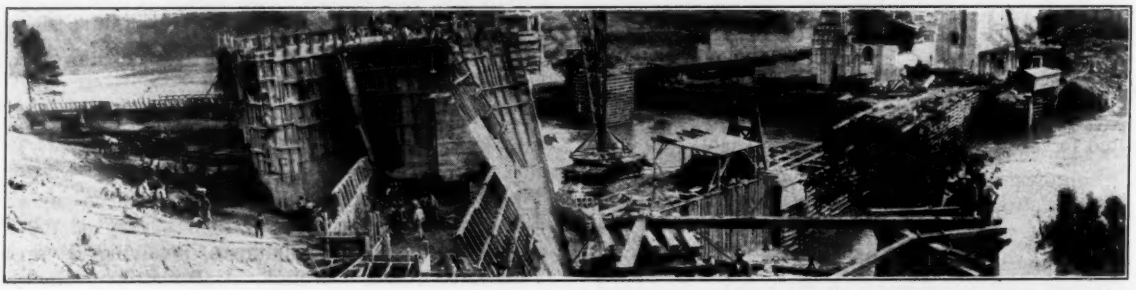


FIG. 1. CONSTRUCTION WORK PROGRESSES AT BARTLETT'S FERRY DAM ON CHATTAHOOCHEE RIVER

FIG. 2. TRACTORS HAUL 185,000 CU. YD. OF DIRT FOR WINGS OF DAM

Stone and Webster, Inc., builders of the dam, used caterpillar tractors for the task, each tractor pulling three 3-yd. dump wagons. Two power shovels loaded the wagons from the borrow pit. The earth was laid in six-inch strata, each layer sprinkled and then compacted by a roller.

Old Locomotive Boiler Remodeled for Stationary Use

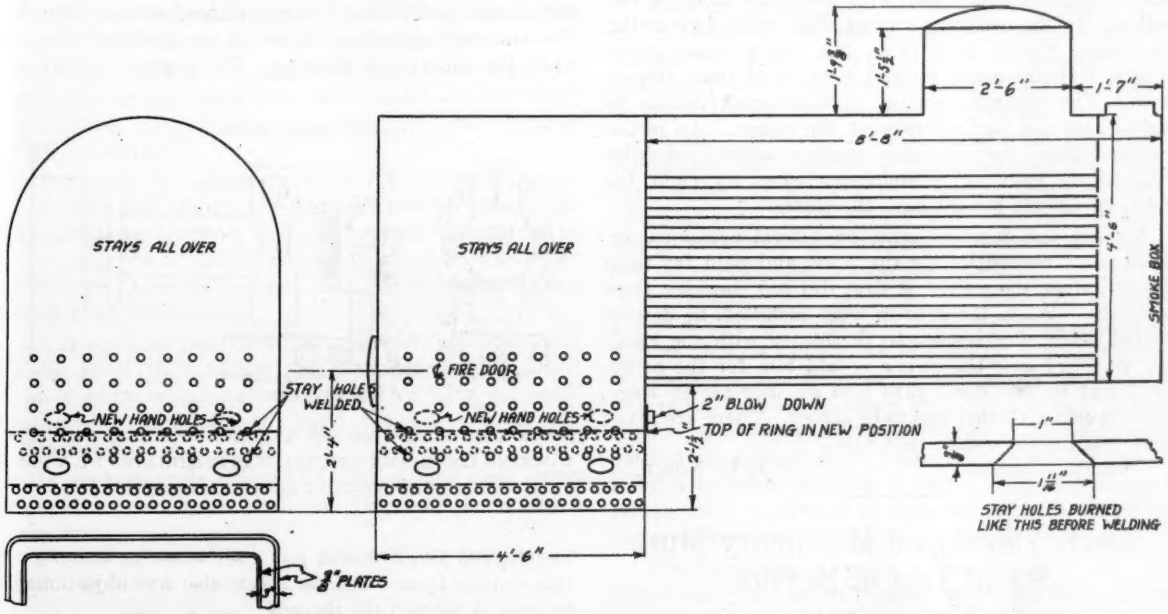
FOR THE PAST 10 yr. we have been using a locomotive boiler for our steam needs and the inside of the fire-box a few inches above the mud ring became wasted away on the fire side. Last year we had our oxy-acetylene operator build this up, but the corner seams became leaky due to the heat of welding.

All other parts of this boiler were in perfect condition, and we felt that it was possible to save it. We decided that if the boiler was cut off at a line through the center of the first row of stays and the mud ring shifted to a new position, we would have a boiler practically new.

In the accompanying figure is shown the arrangement of the tubes and handholes. A cut was made just above the handholes and through the center of the first row of stays, the plate here being in perfect condition, but the second row of stays had to be taken out as they would be too near the mud ring and be the cause of holding mud, also they would make it hard to wash out the boiler if left in.

This meant that all those stay holes, and the half holes of the first row through which the cut was made, had to be welded. As there were nine stays on all sides, both inside and out, it meant 72 holes and 72 half-holes that our oxy-acetylene operator had to weld in.

After this the ring was placed in its new position, the holes laid off on the outside, a $\frac{5}{8}$-in. drill first run through and then all holes reamed to $\frac{11}{16}$ in. so as to take $\frac{3}{4}$-in. rivets. Since a new blow-down connection had to be provided this was placed in the back side of the fire-box as shown. It was originally on the left-hand side, but we considered it in a safer place in the new position as shown.



THIS SHOWS THE METHOD OF LAYING OUT THE NEW STAY AND HAND HOLES BEFORE WELDING

In preparing the plate for welding, the operator first tried to fill in the holes by beginning with square edges but found that when he chamfered off the edge of each hole to a 45-deg. angle they filled in much more easily and made a better job.

After riveting was finished, a pressure of 250 lb. was put on the boiler and everything was found satisfactory. We now have a boiler as good as new.

Conception Bay, Nfld. J. B. PETRIE.

Auxiliary Boiler Room Equipment Is Valuable

IN SPITE of all that has been written on the subject, it is surprising how many plants have no temperature gage on their feed-water heaters, perhaps not even a thermometer anywhere in the boiler feed-water line. The boiler tender places his hand upon the feed pipe and, if it feels warm, he lets it go at that and is quite satisfied that everything is satisfactory.

Recently, I visited a number of boiler rooms and in many failed to note any provision made for indicating the feed-water temperature. A reliable thermometer can be bought for a few dollars and installed by the engineer at the cost of a pipe fitting or two. An engineer who would be satisfied with a temperature of 160 or 170 deg. by the hand-feeling method might not be satisfied with anything under 200 with a visible temperature record.

Consider the extra dollars it means to the owner to have the feed-water temperature increased 30 or 40 deg., perhaps at little or no extra expense beyond the installation of a temperature gage or thermometer. The trouble with a good many engineers is lack of persistence. If they ask the owner for a thermometer and he promises but fails to fulfill the promise, the engineer should again mention the matter. Perhaps the engineer fails to impress the owner with the importance of the matter. To the ordinary human with little engineering knowledge, which description fits many small plant owners, a thermometer request may be of small importance. The engineer should consider such details or possibilities and again interview the owner. An owner is often blamed for some such omission as no feed-water temperature gage or thermometer when by right the engineer himself should have the blame.

I know one engineer who, on several occasions, ordered small necessities for the plant and paid for them himself, since the owner at first did not consider them necessary. When the articles were installed, he demonstrated their effectiveness to the owner with the result that in every case the owner repaid him for the equipment and in two cases gave him an increase in wage. All this owner needed was to be shown. There are many more small plant owners like him.

Toronto, Canada. J. E. Noble.

Newly Developed Machinery Must Stand Test of Service

Probably there are engineers of your acquaintance who adhere to the old rule, "Never install a machine that is new and that has not been tried out thoroughly in actual service."

It is a good rule to follow if you want to be "safe." Many a machine that has looked good on paper, and that has given good results in the experimental laboratory, has failed dismally when put to work in the plant. It is difficult to call to mind a single successful machine that has not come up through the long process of gradual practical development. New inventions generally are crude and impractical.

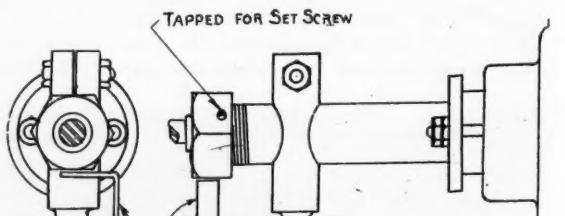
On the other hand, there are some who appear to follow the policy: "I'll try anything that looks good." They are willing to take chances, at the same time endeavoring to exercise good judgment, and they often succeed. If it were not for those who are willing to try new things, there would not be much progress in this world. There always must be a first trial for any new machine. Henry Ford is commonly cited as an example of one who is unafraid to try out radically new devices and methods.

Large concerns can better afford to experiment with new machinery than can the smaller ones, but my own personal opinion is that most of the experimenting is allowed to fall upon the shoulders of the great mass of smaller concerns. The big fellows are more conservative. But what I have principally in mind is this thought: Before anything can be called a positive "success," however attractive it may appear on paper, it must be able to withstand the acid test of service. Sometimes it takes many years before a machine becomes a real money-earning success.

Newark, N. J. W. F. Schaphorst.

Packing Nut Trouble Eliminated by Simple Means

As shown in the accompanying figure, the hexagon stuffing-box nut is used to retain the packing around the cutoff valve stem of a Buckeye riding cutoff, cylinder valve engine. Trouble was experienced several times by this nut working loose and letting the packing blow out while the engine was running. The engineer before me had tapped this nut and put a set screw in it but even this worked loose. The set screw also was objectionable because it marred the threads.



SINCE A SET SCREW DID NOT KEEP THIS PACKING NUT FROM WORKING LOOSE, THE TROUBLE WAS ELIMINATED BY A PIECE OF ANGLE IRON BOLTED ALONGSIDE

To overcome this difficulty, I fastened the angle shown to the wristpin bearing strap, as shown. This permanently ended all trouble from that source. This engine is supposed to run without any attention except starting and stopping, so that everything tending to eliminate trouble is welcome.

Moline, Ill. Robert A. Althaus.

Engineering Is Not a Stepping Stone to Something Higher

Under the above heading the communication of Morris Richard, in the August 1 issue, contains a clear and accurate review of the economic position of the engineer as it has been in the past and is to a considerable degree at present. In this respect I most heartily agree with his statements, but I do not think it necessarily follows that the same conditions either should or must continue in the future.

Unfortunately for their own good, engineers as a class appear to have made it an article of faith that the cultivation of a highly efficient inferiority complex is a virtue rather than a vice.

Our modern civilization fundamentally is mechanistic, while other eras have been marked by the development of agriculture, religion and art. The outstanding achievement of the present age, however, is the astonishing advance which we have made in our understanding and control of the physical forces of nature. To a large extent this has been the work of the engineer, and he has placed at the disposal of mankind a weapon of such stupendous power that upon the manner in which we use it will depend the fate of our civilization.

The fundamental question appears to be, shall the technically trained man, who has developed this great power, claim the right to take his full part in its direction and application, or should he, as he has so generally done in the past, hand it over to the financier and politician?

For the most part, the answer lies with ourselves. We must decide whether we are to stand up and take our part in the world of men, or whether we shall be content to be merely the hired servants of others.

Bergson said that to analyze a thing, is to express it in terms of something other than itself and he might have added that as a rule the choice of terms is practically unlimited.

Generally the engineer analyzes his problems in terms of stresses and strains or thermodynamics, but as Mr. Richard has suggested, the last analysis often must be made in terms of dollars and cents and economics. We should not, however, assume that this removes it from the field of engineering.

Too often at just about this point we throw up our hands as if the problem had progressed beyond the limited range which we ourselves have set for our intellectual activities, and we hand the job over to the money-lender.

It has been truly said that when they lose their vision the people perish; so shall we engineers if we don't wake up.

Newark, N. J. JAMES O. G. GIBBONS.

New Chief Engineer Should Study His Men

DURING MY 30 yr. experience as engineer in charge of power plants I have been convinced that the crucial period in an engineer's life is when he is given charge of a plant which is new to him. As I have had this experience several times, a letter from me upon this subject may be of interest.

To the man placed in charge, the plant either may be new in design or construction or it may be old but representing novel principles of construction; but of whatever nature he will be sure to find conditions and practices with which he is not familiar. Probably it will be during the first few weeks of his occupancy of this important office that the severest test of his ability will be had and it depends more or less upon how he fills his predecessor's shoes during those first few weeks as to whether or not it will be his first and last few weeks at that plant.

Perhaps the hardest thing to study and understand, for the practical man, is the thorough characteristics of the employes under him, the mere study of the machinery being comparatively simple. To many it is a hard matter to discharge a man who has been working at a plant for some years, and even though it is plainly demonstrated that he is not performing his duties properly, it sometimes leads to suspicious assumptions on the part of other employes that the new chief is exercising his authority unjustly.

For a new chief, therefore, it requires common sense and good judgment as it is important that he have the confidence of his assistants; otherwise, the efficiency and the economy of the service may be detrimentally affected. He can form a fair estimate of the value of the men under him from the condition of the apparatus throughout the plant, the economy in the use of oil, fuel, and other supplies, the discipline and order which they show and their readiness to serve. Such things will mean much in determining the characters of the men with whom he will have to work.

Personal investigation is the principal requisite for an understanding of the machinery. Starting with the boilers, follow every steam pipe to its destination and note every point which might mean lack of economy or safety. Do not take anything for granted.

In one plant where I had become the new chief I found that the former chief (who had been discharged) apparently had wilfully or carelessly made a number of wrong notes in the record book, since usually I verified personally all data pertaining to the boilers, engines and other equipment as soon as possible.

In looking over a new plant, I kept two objects in mind—safety and economy, leaks and radiation being the two obvious losses to which I always attended as soon as possible. Any flapping or apparently slipping belt was noted and many other little items which perhaps a man used to the plant would overlook. Every item was entered in a small book. Every chief should make it a habit to mark down in a pocket book each thing he thinks could be altered or repaired or replaced. Often the memory alone will prove an unreliable servant.

The foregoing are only a few things a new chief should do. As soon as possible he should have all data available which will enable him to meet his employer with arguments of a convincing nature when making requisitions for new machinery or material.

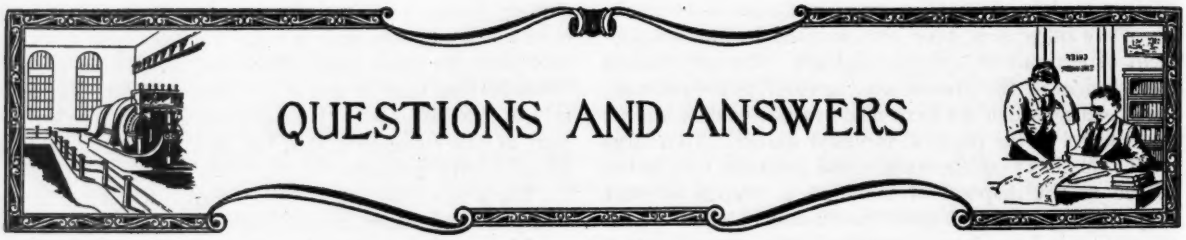
Toronto, Canada. JOHN THORN.

Boiler Fronts Cleaned with Hot Water

DID YOU ever try to clean the whiskers from the plates of a water tube boiler? I had four large boilers that looked as if they were trying to rival Mammoth Cave for stalactite and stalagmite formation. We tried chisel and hammer, but after a day the cleaning was progressing so slowly that I tried the effect of a stream of cold water. This was somewhat better but, acting on a suggestion offered by one of the firemen, I tried hot water from the boiler feed line and we cleaned all four boiler fronts in one day.

We then started painting with oil and graphite but found progress too slow with a hand brush, so we made an air spray from a quarter inch pipe and a half inch tee. We painted all the nooks and corners, front and rear, in 4 hr.

Vermillion, S. D. L. A. COWLES.



QUESTIONS AND ANSWERS

Principles of Transformer Connections

IN THE SIXTH installment of the serial under the above title by V. E. Johnson, June 15 issue, p. 692, it appears that having gone thus far with the discussion

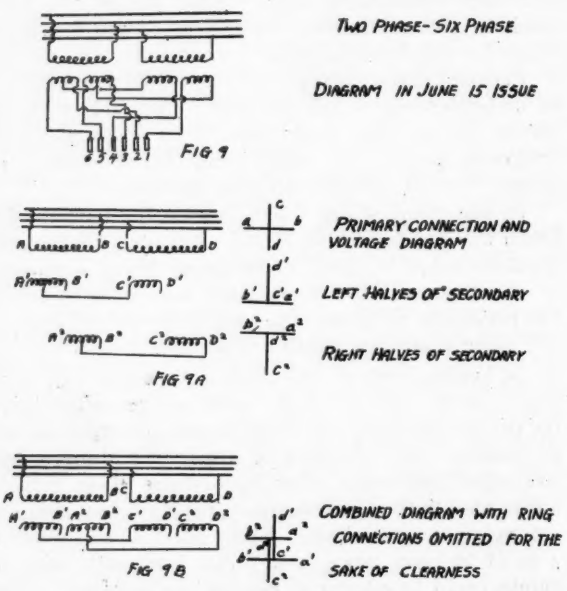

TWO PHASE-SIX PHASE
DIAGRAM IN JUNE 15 ISSUE
FIG 9
PRIMARY CONNECTION AND VOLTAGE DIAGRAM
LEFT HALVES OF SECONDARY
RIGHT HALVES OF SECONDARY
FIG 9A
COMBINED DIAGRAM WITH RING CONNECTIONS OMITTED FOR THE SAKE OF CLEARNESS
FIG 9B

FIG. 1. ANALYSIS OF TWO PHASE-SIX PHASE TRANSFORMER CONNECTIONS SHOWS THE WIRING WAS DONE IN THIS MANNER

of this subject, it would be well to tear apart some of the connections he has shown in order to make sure that all who have read all the previous articles—as I have—certainly will be able to visualize each step in the process of building up one of these complicated connection diagrams as shown on page 693.

For example, at the top of page 694 we read as follows: "Figure 9 shows the actual connections used, while Fig. 10 gives the voltage diagram. It will be seen that the latter consists of two T-diagrams connected in opposition." That is the point in question. I, for one, cannot see that it is composed of two T-diagrams. Perhaps if a "step by step" progress—with all terminals suitably lettered—could be used, it would be much clearer.

Lower down on page 694 he also makes reference to Fig. 12, saying that it will be seen that each transformer has a double secondary and that the three left-hand halves are formed into a closed delta, the three right-hand halves into another delta, and finally that both these are connected at a phase displacement of 180 deg. I can understand the first step clearly—that is, that the three left-hand halves are formed into a closed delta—but the second step and therefore the third, is not entirely clear, because the second coil of the right-hand halves appears to be reversed in the second delta. Is this reversal the means used to displace the phases by 180 deg.? W. B. W.

A. The transformers used for the two-phase to six-phase transformation have single primaries and double secondaries, as shown in Fig. 9, June 15 issue, and here repeated in the upper part of Fig. 1. In order to show the component parts, Fig. 9a has been drawn, in which the secondaries have been separated, and the two T-connections made individually. AB and CD are the primaries, which when connected to the two-phase supply lines, are energized by voltages at right angles to each other as shown in the voltage diagram at the right. The horizontal line a-b represents the voltage impressed

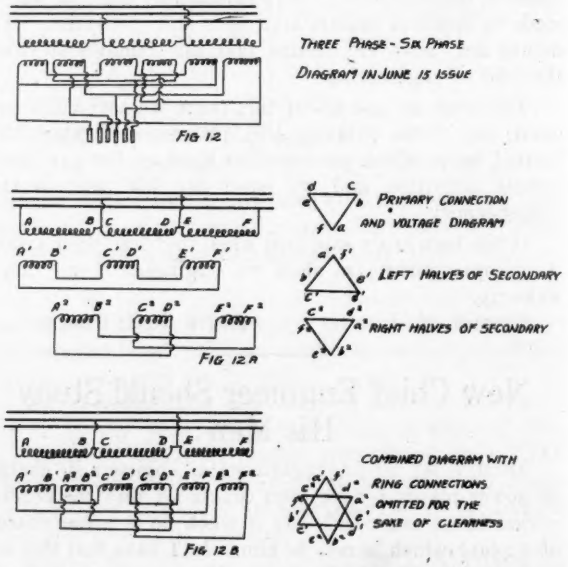

THREE PHASE-SIX PHASE
DIAGRAM IN JUNE 15 ISSUE
FIG 12
PRIMARY CONNECTION AND VOLTAGE DIAGRAM
LEFT HALVES OF SECONDARY
RIGHT HALVES OF SECONDARY
FIG 12A
COMBINED DIAGRAM WITH RING CONNECTIONS OMITTED FOR THE SAKE OF CLEARNESS
FIG 12B

FIG. 2. THIS IS THE METHOD OF WIRING CONNECTIONS FOR THREE PHASE-SIX PHASE TRANSFORMERS

across AB, while the vertical line c-d is that impressed across CD.

The left-hand secondaries are connected in T by joining the terminal C^1 to the middle point of the winding A^1 B^1. The voltage diagram at the right is made up of the line a^1-b^1 parallel to the primary line a-b, and the line d^1 c^1 parallel to c-d. To keep the polarities clear, the secondary vectors are drawn in the opposite direction to those of the primary, indicating that the secondary induced voltages are opposite those impressed upon the primary. The voltage induced in A^1 B^1 is opposite that impressed upon AB, and similarly the voltage induced in C^1 D^1 is opposite that impressed on

CD. The voltage diagram a^1-b^1-d^1 thus shows correctly the phase relations and polarities for the left-hand halves of the secondary windings.

In a similar manner, the right-hand secondaries are connected in T by joining the terminal D^2 to the middle point of A^2 B^2. This is exactly the same as the arrangement of the left-hand halves, except that the connections of C^2 D^2 are reversed. The voltage diagram accordingly becomes a^2-b^2-c^2.

Combining the two connection diagrams gives the arrangement shown in Fig. 9b, in which the lettering of Fig. 9a has been retained. This is equivalent to that of Fig. 10 in the June 15 issue.

The transformers used for the double delta six-phase transformation, have single primaries and double secondaries, as shown in Fig. 12 of this June 15 issue and here repeated. In order to show the component parts, Fig. 12a has been drawn, in which the secondaries have been separated, and the two deltas made individually. The primary voltage diagram shows the phase relations in the coils AB, CD, and EF, by the triangle having sides a-b, c-d, and e-f.

The left-hand secondaries are connected in a closed delta made up of the coils A^1 B^1, C^1 D^1, and E^1 F^1. The voltage diagram is shown to the right, with a^1-b^1 parallel to a-b, b^1 joined to c^1 (as in the connection diagram), c^1-d^1 parallel to c-d, d^1 joined to e^1, and finally e^1-f^1 parallel to e-f with f^1 joined to a^1. This voltage diagram therefore correctly represents the voltage relations in the left-hand secondaries. It will be seen that the coil C^2 D^2 is not reversed with reference to the other coils, but that it is in a different position in the delta, this in turn being equivalent to reversing all of them. In other words, instead of having a delta made up in the order AB, CD, EF, it is now BA,DC, and FE, which is 180 deg. displacement.

In Fig. 2, combining the two connection diagrams gives the arrangement in Fig. 12b, which, except for the detailed lettering, is equivalent to Fig. 12 in June 15 issue.

Milwaukee, Wis. V. E. JOHNSON.

Induction Motor with Light Load Decreases Power Factor

PLEASE EXPLAIN why, since an induction motor lightly loaded draws current in proportion to its load, it decreases the power factor of the line with this light load.

A. When the load on an induction motor is increased, the current in the rotor increases. This increase of current also builds up a stronger magnetic flux which is the same as armature reaction in a d.c. motor. This armature reaction always tends to neutralize a portion of the field flux. The field flux, which is produced by the alternating current through the stator winding, is the cause of inductive reactance in the a.c. circuit. It can be seen that by increasing the load in the motor we increase the current through the secondary which builds up a flux and neutralizing part of the reactance, we allow more current to flow in the primary winding. The more inductive reactance in a circuit, the lower will be the power factor of that circuit. Therefore, if we neutralize part of this reactance by increasing the load, it can be understood that we also increase the power factor.

Maximum CO_2 Obtained from Fuels

I WAS MUCH interested in Mr. Gerend's remarks under the above title in the July 15 issue, p. 815, as I have noticed similar occurrences. I believe the explanation of the Orsat analyses showing higher CO_2 than the titrations is in the volume of the capillary manifold of the Orsat. For example, say the measuring burrette contained 50 c.c. and the capillary 2 c.c., a rather large volume but one which I have seen, then if the CO_2 were actually 10 per cent, the absorption would be nearly 5.2 c.c. or show 10.4 per cent instead of 10.00 per cent, an error of 4 per cent.

It would be interesting if Mr. Gerend would inform us whether any attempt was made to be sure that the large absorptions in his experimental furnace samples really were CO_2 and CO and not some of the tar or acid products of wood distillation, since it will be noticed from the tabulation, in which the first three columns are as given in Mr. Gerend's letter, that if the residual gas not shown in the analysis is atmospheric nitrogen, then the oxygen accompanying it, that is 20.8 ÷ 79.2 of its volume would account for practically all of the free oxygen present.

CO_2	O_2	CO	Residue— (Nitrogen) ?	0.263 N_2
10.0	17.0	4.0	69.0	18.1
22.0	13.0	9.0	56.0	14.7
42.5	7.5	17.0	33.0	8.7
56.6	0.8	38.6	4.0	1.05

It would thus appear that in every case the absorption was mainly of distillation products.

As shown by exact research on the heating value of cane sugar in connection with the standardizing of calorimeters, apparently the oxygen in sugar and wood fiber, which are similar compounds, is combined with the carbon in a different way from that in coal, alcohol and such substances. For instance, taking the heating value of cane sugar by Dulong's formula, which deducts the oxygen equivalent of the hydrogen from the total and supposes the remaining carbon and hydrogen will develop their full heating value, we get only 6130 B.t.u. per lb., whereas calorimeter determinations show 7130 B.t.u. per lb.

Alcohol, on the other hand, in which the hydrogen and oxygen are known to be in rather direct combination gives a heating value by Dulong's formula of 12,990 B.t.u. per lb. while calorimeter determinations show around 12,700 B.t.u., indicating that the structure of the sugar molecule is quite complicated as is also witnessed by the variety of compounds formed when it is heated and broken up compared with the simple vaporizing and combustion of alcohol.

Freak analyses, such as Mr. Gerend mentions, are often obtained in coal firing when large amounts of gas are being given off, though in such cases the maximum CO_2, with little oxygen or carbon monoxide, is down around 16 or 17 per cent, due to excess of hydrogen in the volatile matter. In the old days of good hand firing one would occasionally get analyses of about 18 per cent CO_2 without oxygen or unburned gases but it was then easy for the fireman to slide over and produce a wasteful quantity of carbon monoxide.

New Haven, Conn. H. D. FISHER.

EDITORIAL COMMENT

Industry and Electricity Extend New Frontier

Electricity, through modern power transmission systems, has made life more agreeable for suburban and rural dwellers resulting in the beginning of an important movement from the cities. Through improved electric transportation it is possible for a city worker to live far from his place of employment and enjoy the utility comforts of the urban dweller, with the added benefits of the fresh air and open country of the small community. This movement from the cities is not confined to individuals but extends to industries as well, bringing a new era of more uniform distribution of prosperity and more even growth of population.

Undoubtedly the greatest visible change has been in the strictly rural districts where electric drive for milking machines, brooders, feed choppers, churns, etc., has replaced the old manual method with a considerable saving of time and expense. Small as such loads appear, they have been sufficient to build up important networks of transmission lines in many districts. Fed usually from some interurban electric traction feeder, lines are often pushed into non-productive territories at a loss, with the prospect of building up the community. Such action is reciprocal. Electricity builds up the country and the country in turn increases the electric load, reducing unit overhead charges.

Transmission costs, long a bulwark against which power companies vainly battered, are beginning to show signs of disintegration as the decentralization movement of industry and population gains ground.* A recent electrical survey of nine middle western states, Illinois, Indiana, Iowa, Kentucky, Ohio, Michigan, Minnesota, Missouri and Wisconsin, predicts a population increase of 41 per cent in the next 24 hr. with an annual power consumption of over 63,500,000,000 kw-hr. at the end of that period.

We are on the verge of an industrial epoch which will rank in historical importance with the industrial supremacy of New England during the period of direct water power drive; an epoch in which the new electrical frontier will be pushed to every corner of the country and which, for the next half century, will have an important effect on electrical development.

Industrial Museums as Educational Institutions

Too often in our efforts to advance we forget to look backward over the course that has been traversed and continue, unknowingly, to work along lines that have already been developed. Particularly is this true in a country that has no long industrial history back of it. Just why this should be seems difficult to answer but it is a fact that individuals in nearly every generation go through the same failures as were experienced in previous generations regardless of all the literature available on the subject of the experiment. The patent offices are full of ideas that failed because something better was already known to industry. Engineers in one industry have been known to apply some principle or device common in another industry to their work and secure revolutionary results. Without this diversity of knowledge progress would have been delayed. The question comes, how can an engineer specializing in one industry obtain a sufficiently diversified knowledge of other industries to keep him at the top notch of his own?

Perhaps the answer to this question will come with the establishment of industrial museums, two of which are now being promoted in this country, one to be located in New York City, and the other just announced as the gift of Julius Rosenwald to occupy the reconstructed Fine Arts Building of the World's Fair in Chicago. If these museums are properly equipped to represent the development of various industries up to modern times, showing typical equipment as a matter of history, an engineer could gain a wonderful amount of information or refresh his memory on other industries than his own in a remarkably short time. For the latest ideas in equipment used in an industry, a visit annually to a comprehensive exhibit and talks with representatives of manufacturers will keep an engineer in touch with a wide range of development.

Due to the rules of many industrial plants, lack of time or to the expense involved, few people are permitted to visit many representative plants in various industries and it is to be hoped that these museums will be sufficiently complete to give the visitor something more than general ideas. They should be educational institutions where the student will get a visual conception of the industry, its equipment, processes and materials used, the number of people engaged in it, their conditions of work and living and the importance of the industry to the country. To make these museums of greatest value, will require the support and cooperation of the engineers in all industries. Here is another opportunity for service in a worthy civic undertaking.

Ice and Iceless Refrigeration

Running an ice plant has its ups and downs as well as other industries. Every engineer knows the importance of a high load factor for economical production, yet your ice manufacturer with his capital tied up in expensive equipment, is powerless to control his load factor. He must depend on the vagaries of the weather. Even south of the Ohio river, where one would expect more uniform temperature conditions, the load factor of ice plants varies from 100 per cent in July and August to 11 or 12 per cent in January and February.

Under these conditions an ice manufacturer cannot

continue operation, unless he has other means of support. Usually he combines the selling of ice in summer with the selling of coal in winter. But even then the same wagons or trucks cannot be used for coal as for ice. He must have separate sets of hauling equipment.

Added to these difficulties, a new worry has arisen. In many cases ice manufacturers are beginning to feel the results of electric refrigeration in households and stores. Some are beginning to show real alarm. One large ice company has started to combat competition by newspaper and magazine advertisements reproducing part of a bulletin sent to electric power companies by a large manufacturer of electrical refrigerators, stating that the annual power bill of a household refrigerator is equal to 32 washing machines or 50 electric fans or 29 vacuum cleaners. It is further charged that these types of refrigerating machines are noisy and there are excessive maintenance costs. This is one side of the controversy.

On the other hand, a number of prominent engineers are of the opinion that the ice manufacturers who are alive to the situation and have installed economical equipment, have no cause for alarm. There is room for everybody. The keen edge of competition will be felt only by those ice manufacturers who have been running their plants as they were originally built and operating in a haphazard manner with no regard for production costs, quality of ice, or the rights of the ultimate consumer.

A prominent firm of consulting engineers has seized the opportunity to appeal to the ice manufacturers to overhaul and remodel their old plants in order to meet this new competition which they believe is a blessing in disguise. They are of the opinion that the ice-making industry needs this competition to stimulate progress. We join them in sounding this warning: "This is an age of progress. If you don't keep abreast of the times, you fall behind."

Automatic Controls for the Steam Turbo-Generator

Developments in automatic equipment for hydro-electric plants and substations for industrial, railway and power distribution systems have been extremely rapid during the past few years. In the boiler room, automatic control equipment of many types has been developed that gives better control of draft equipment, stoker and pulverized coal feeder speeds and other apparatus than the operator can possibly give by hand. At the present time, the basis for selection of such equipment is economic rather than engineering.

In the steam turbine room, however, we have not seen automatic equipment applied to so great an extent. Remote controls for switches, to be sure, have become common. Now, prominent engineers are suggesting that automatic synchronizing and protective relay equipment can be applied to steam and hydraulic turbine-generators of almost any size.

To those who have seen this equipment function in small hydro plants and substations and in a very few steam plants, there can be little question that its use with steam-driven units is feasible. For example, the process of synchronizing, particularly by the use of apparatus that duplicates the manual operation—bringing the units up to speed, putting on the field and throwing in the switch when the unit is in phase—is smooth and certain, the absence of electrical and mechanical disturbance being its chief merit.

Objection is made to the use of protective relay equipment on turbine-generators on the ground that it is unnecessary and sometimes, because of load conditions, it is impossible to shut down the unit, if a bearing begins to run a little warm. That objection, as well as others, has lost some of its force in recent years, in view of the interconnection of power systems to carry large loads.

Furthermore, the protection that can be obtained against disturbances in generator windings might often be worth more in saving repairs than the economic value of keeping the unit on the line for a few hours.

In short, we feel that it is worth while for engineers to consider carefully the value of automatic synchronizing and protective equipment as applied to the steam prime mover. In some cases, it may not prove worth while. In other cases, when properly applied, it will doubtless be found to justify itself as it has in the hydro-electric plant and the substation.

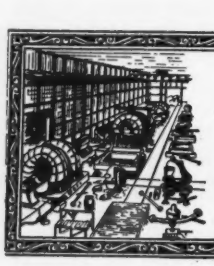
When Figures Lie

There is an old and trite saying to the effect that while figures are incapable of falsehood there are among us certain prevaricators who are mathematical contortionists. In repeating that old adage most of us are sure that the indictment falls on the head of someone else.

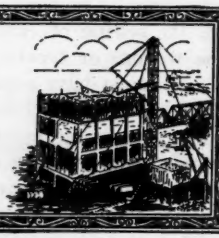
Recently we saw the self-compiled figures on volume and extent of business for three manufacturers in the same line of endeavor. One such manufacturer undertook to prove, by statistics, that he supplied 58 per cent of all his particular type of commodity used in the United States. Another claimed 41 per cent of the nation's business in this field, while the third, being more modest than the rest, set his ratio of total sales to volume at 37 per cent. While we have made no check on the matter, there must be at least a dozen such manufacturers in the country. Just where the remaining nine do business is not known, but, since by their own admissions, the three do 136 per cent of the business, evidently, in this particular field, the parts are greater than the whole.

Figures like these are treacherous things on which to base business policies or sales quotas and they clearly indicate the need for reliable, accurate manufacturing statistics. Such market analyses or production surveys obviously cannot be made by a single producing member, nor can an outside research firm intelligently provide such service. The obligation for and the work of compiling such statistics should revert to the industrial association, which is, or should be, unbiased, fair and just, having the natural advantage over an outside research firm in that it is fully acquainted with all the ramifications of its chosen field.

There is real need for industrial surveys and market analyses since their compilation would eliminate much of the dangerous and costly guesswork now indulged in by individual manufacturers. We recommend the consideration of this suggestion to the executive secretary of every industrial association.

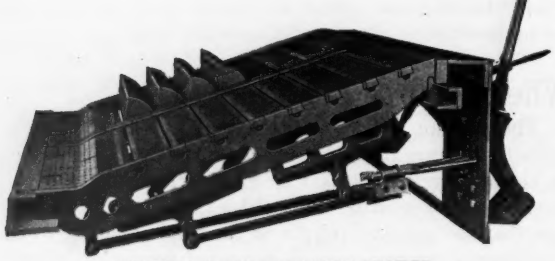


POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS



Hand Stokers Give Positive Feed

STOKERS for manual operation are becoming an important feature of moderate size plants and a newcomer in the field is worthy of attention.



NEEMES HAND-OPERATED STOKER

In the Neemes hand-operated stoker illustrated, the grate bars are proportioned to give ample strength and cooling surface with a deep apron on the bottom having a constant angle of arc when tilted so as to prevent sifting of coal to the ashpit and wedging of fuel or clinkers between stoker bars. Deep, solid edges are designed to prevent burning and slots widened below the top surface avoid clogging of ashes.

Side bars anchored only at the forward end, resting in recesses at the rear, allow for free expansion, while the deep girder is designed to provide large radiating surface and prevent danger of warping. By setting the side bars at 15-deg. angle to the horizontal, use of a shallow ashpit is possible which, in many cases, solves a difficult installation problem.

Stoker bars and dump plates are held securely in position by lock boxes which cover the journals, protecting them from fire and ashes, while holes at the bottoms of the journal recesses provide for self cleaning.

For operating the bars, long levers give easy manipulation with stops on the rods to prevent overtravel and a dog on the dumping toggle to hold the dump plate in normal position. Dump plates are operated independently of bars and are of shape to assure being completely covered with fuel after dumping. The forward end forms a continuation of the grate bar surface and has slotted air space to ensure combustion of fuel. In dumping, the forward end of the plate rises to prevent sliding forward of fuel from the bars with consequent ashpit loss.

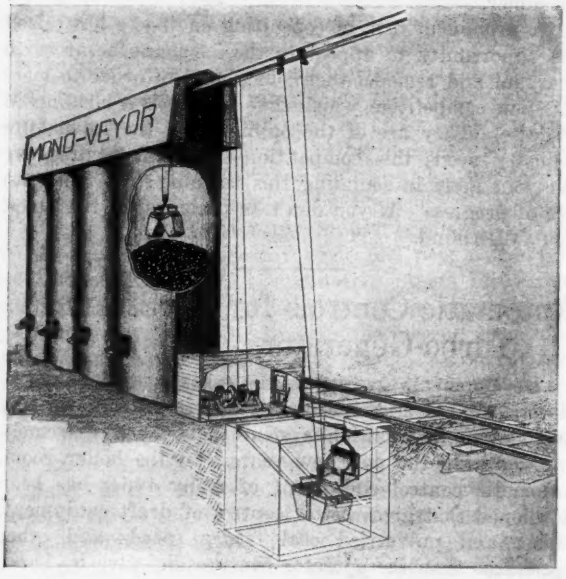
Coal is fired onto the forward dead plate and worked back by operation of the stoker bars, the forward half and back half being worked in series so as to keep the fuel bed of uniform depth.

These stokers are the product of the Neemes Foundry, Inc., of Troy, N. Y.

Monorail Conveyor Built for Small Plants

TO COMPLETE its line of material handling equipment embracing belt conveyors, skip hoists and trolley systems, the Galion Iron Works & Mfg. Co. of Galion, O., announces its new monorail conveyor known commercially as the Mono-veyor.

Cars are dumped into a track hopper from which the bucket is filled by gravity. The bucket is then



SIMPLICITY OF CONTROL AND OPERATION ILLUSTRATED BY TYPICAL INSTALLATION

raised by a special two-lever electric hoist, carried to the proper place and lowered. A trigger on the bottom of the bucket trips upon contact with the pile, causing the bucket to open and deposit its contents with little possibility of breakage. Construction and balance of the bucket is such that it closes and locks automatically after dumping.

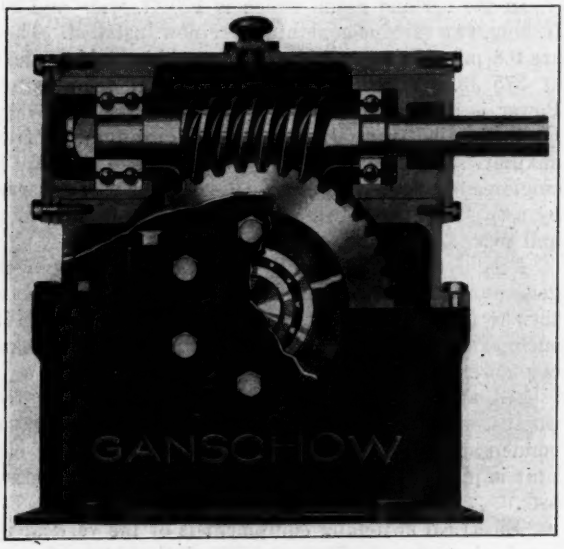
Flexibility to meet demands of yard layouts, simplicity of operation and minimum breakage are given as the outstanding features which should appeal to power plant owners.

New Speed Reducer Has Reversible Shafts

FOLLOWING an extended development campaign, the Wm. Ganschow Co., of Chicago, Ill., has placed the new Ganschow worm gear power transformer on the market.

Completely enclosed, all parts are protected by the cast-iron housing which is built symmetrical so that the worm or gear shafts may be reversed at any time. Special bronze gears are driven by a 3½ per cent nickel steel worm with ground threads.

Ball or roller bearings of liberal proportions are used depending upon the service, the front radial worm bearing being free floating to take care of elongation of the



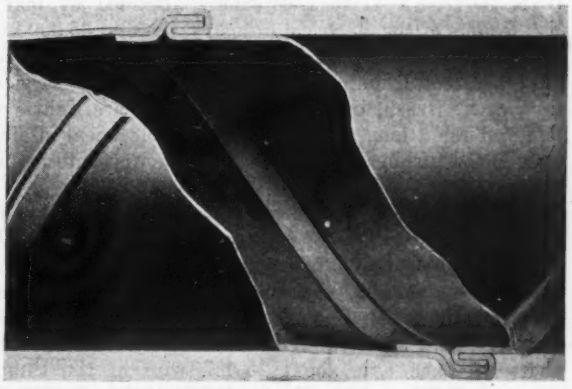
VIEW OF COMPLETE UNIT WITH HOUSING CUT AWAY TO SHOW CONSTRUCTION

worm or distortion of the housing due to heat. The lower part of the housing forms an oil reservoir, the gear operating in a bath of oil.

Spiral Rivetless Pipe Has Lock Seam

RECOGNITION OF THE need for a light, easy-to-handle, but strong pipe, which would permit free and easy flow of materials, has resulted in the development of Naylor Spiral Lock-Seam Pipe—a pipe designed to combine economy and light weight with unusual strength and wearing qualities. A strip of sheet steel is wound into spiral shape but, instead of riveting the edges, they are automatically flanged and formed into a 4-ply lock-seam laid up on the outside of the pipe, as shown in the illustration. The pipe is formed in a continuous piece and then cut in desired sections up to 40 ft. in length. It is made from No. 16 to No. 10 gage sheets and from 4 in. to 30 in. in diameter. Plain, galvanized, painted and asphalted Spiral Lock-Seam Pipe may be had to meet varying requirements. It is manufactured by the Naylor Spiral Pipe Co., Chicago, Ill.

Naylor pipe is not rolled, but is wound upon a lathe-turned arbor under high tension and the edges of the steel are interlocked at the same time.

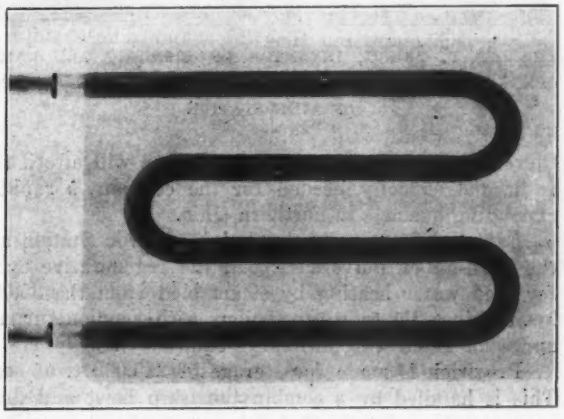


SECTION OF SPIRAL LOCK SEAM PIPE, SHOWING CARBON STEEL WEARING STRIP INSERTED IN PIPE DESIGNED FOR ABRASIVE MATERIALS

For handling abrasive materials a high carbon steel wearing strip is formed with the joint; this strip is, of course, omitted in pipe designed for air, gas, water and non-abrasives.

G. E. Develops New Heating Element

IN THE ACCOMPANYING photograph is shown an X-ray view of a novel form of heating element recently developed by the General Electric Co. This element which is known as Helicoil Sheath Wire consists



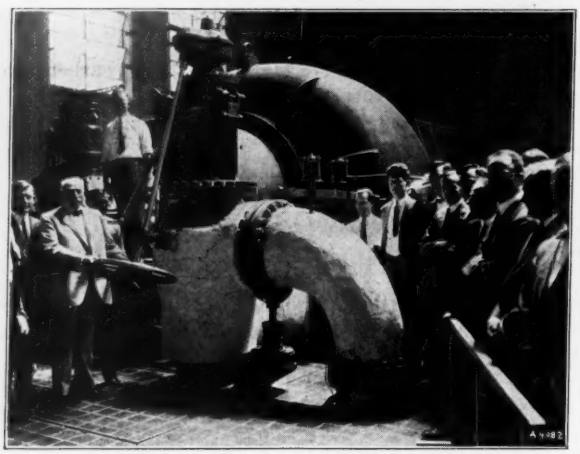
X-RAY PHOTOGRAPH OF HELICOIL SHEATH WIRE UNIT CAST INTO AN IRON PLATE

of a heating element of nickel chromium wire in the form of a helix surrounded by a dense, highly compacted insulating powder, insulating it from the sheath or casing. The heating element is connected on each end to terminal rods which are securely anchored in the tube. After terminal connections are attached to the terminal rods the heating unit is completed and ready to be installed.

C. E. I. Co. Starts First Unit of New Avon Station

ON AUGUST 4, at a ceremony attended by many leaders of the electrical industry, the first 35,000-kw. generating unit of the new Avon Station of the Cleveland Electric Illuminating Co., was put into service. Charles F. Brush, inventor of the Brush arc light system and for a long time prominent in electrical affairs, opened the turbine throttle and put the unit into actual service.

Avon Station has an initial capacity of 70,000 kw. in two units; the ultimate capacity will probably be 300,000 kw. It is to be interconnected with Lake Shore station by a 132,000-v. transmission line about 30 mi. long forming a belt line around Cleveland and insuring uninterrupted service. Avon Station is located on the shore of Lake Erie about 25 mi. west of the Public Square of Cleveland and about five miles east of the Lorain. It is the third large plant to be built by the



CHARLES F. BRUSH, INVENTOR OF ELECTRIC ARC LAMP, OPENS THROTTLE OF FIRST 35,000-KW. UNIT AT OPENING OF AVON STATION

Cleveland Electric Illuminating Co. and will afford the additional capacity needed for the company's rapidly expanding business in northern Ohio.

Essential features of the design of Avon Station are the burning of pulverized coal, the regenerative cycle for feed water heating by steam bled from the 35,000 kw. turbines, the twin type boilers with common furnace and some interesting switching equipment.

Provision is made for storage of 275,000 t. of coal. This is handled by a combination skip hoist and drag scraper. In going to the coal preparation house, it is reduced to 1¼-in. size by a breaker, then is conveyed to storage bins in the preparation house. From these it flows to a steam-heat drier that removes all moisture over 3 per cent. It goes then to the impact pulverizing mills; the pulverized coal is removed into a cyclone separator and is then weighed and sent by screw pumps and compressed air to the pulverized coal bunkers in front and above the boilers. From these bunkers, coal flows to the simplex feeders, which send it to the fan-tail burners, of which there are 16 to each boiler.

Boilers are of the twin Stirling type with a common furnace, fired from opposite sides, built with air-cooled side walls and ash hoppers. A water screen with an effective heating surface of 792 sq. ft. is connected into the circulation of each boiler. Ash is taken out through air-operated gates and disposed of by a sluiceway.

Four twin Stirling boilers are installed, operating at 390 lb. pressure and a total steam temperature of 725 deg. F. Each boiler has 30,600 sq. ft. of water heating surface, 6550 sq. ft. of superheating surface and 21,120 sq. ft. of economizer surface. Furnace draft is supplied by a 195,000-c.f.m. induced draft fan and a reinforced tile concrete chimney 17 ft. in diameter at top and 175 ft. high, one chimney serving two boilers. Boiler feed pumps are centrifugal, turbine-driven units. An automatic combustion control system of the steam flow-air-flow type is used.

In the turbine room, which is 100 ft. wide and 216 ft. long, two turbine-generators are now installed. These are 0.8 p.f., 17-stage, 1800-r.p.m. machines taking steam at 375 lb. pressure and 700 deg. total temperature. Power is generated at 13,200 v., three-phase, 60 cycles. Excitation is from direct-connected exciters or from auxiliaries. These turbines exhaust into 42,000-sq. ft. single-pass surface condensers. Each condenser is served by a two-stage steam air ejector, two condensate pumps and two 43,500-g.p.m. circulating pumps.

Feed water is heated by passing first through the generator air coolers, then through the steam air ejector, then to a closed heater taking steam bled from the 14th turbine stage and finally to a small barometric jet heater condenser.

All auxiliaries are motor-driven except boiler feed pumps, which are turbine driven. Duplex drive for one condensate pump and one circulating pump on each unit is provided, as well as for direct-current generator sets.

Electrical switching equipment is of the vertical isolated phase type. Three banks of three transformers are used, each bank consisting of three 15,000 kv.a. 13,200 to 132,000 v. self-cooled transformers. Station power is supplied by 13,200/2300-v. transformers, and is stepped down further to 440 v. for small motors and 122 v. for lighting. Two 480-amp-hr. storage batteries float on the control bus.

CONTRACT FOR a six-million-dollar automobile plant, one of the largest industrial building contracts in the country let this year, has been placed with the Austin Co., Cleveland, for the new Pontiac plant for Oakland Motor Car Co., to be built at Pontiac, Mich.

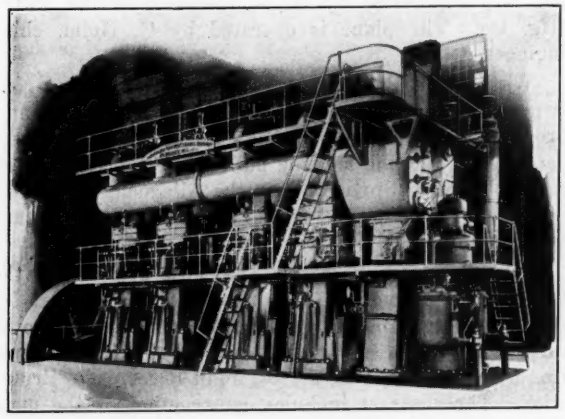
Work was started July 23. This construction contract followed close on the heels of $150,000 engineering contract which was placed with Austin in June. The new plant comprises over 2,000,000 sq. ft. of floor space and includes a single-story motor plant 455 by 880 ft., an assembly building 180 by 1260 ft., a foundry 300 by 700 ft, and a car storage building 432 by 760 ft.

The Pontiac plant site covers more than 100 acres of land on the Grand Trunk R. R., about one mile from the Oakland plant. More than 4 miles of railroad siding with loading docks are to be built to accommodate 200 cars per day. The Fisher Body Co. has a plant adjoining the new Pontiac plant. Bodies will be furnished the Pontiac plant by means of conveyors. Work is to be completed in January, 1927.

Large Diesels for Mining Service

REFLECTING the growth and the increased importance of the Diesel engine in the industrial field, the decision of the Commerce Mining & Royalty Co. to install three 2250-hp. units is received by engineers as an important step towards the application of larger units.

The Commerce Mining & Royalty Co., with headquarters at Miami, Okla., is one of the world's largest producers of lead and zinc. Operations are confined to the Tri-State field, principally in Ottawa County of southeast Oklahoma and Cherokee County of southwestern Kansas, a section which last year produced more than 50 per cent of America's output of lead and zinc. Fifteen mines and mills and the electrified Northeast Oklahoma Railroad are operated by this company.



THREE ENGINES OF THIS TYPE WILL REPLACE PURCHASED POWER AND SEVERAL SMALL PLANTS

These three four-cylinder, two-cycle, single-acting engines will be built by the Nordberg Manufacturing Co. to replace a combination of purchased power and a number of small and medium-sized steam and gas engine plants located at widely separated points. The power plant will be located at Gardin, Okla., and transmission lines, the maximum about 14 mi. long, built to the various places where power is used. Each engine will be direct connected to a 2000-kv.a., 2300-v., 3-phase, 25-cycle Westinghouse generator and the plant laid out to facilitate future expansion and permit the installation of additional units.

News Notes

ON SEPTEMBER 23, 24, and 25, the sixth annual convention of the Great Lakes Division of the National Electric Light Association will be held at the French Lick Springs Hotel, French Lick, Indiana. Men of national prominence will present papers, somewhat fewer in number than has been the case in past years, but all carefully prepared, and with time allowed for discussion. Among those who will speak will be R. F. Pack, President of the National Electric Light Association; Dr. Matt Luckiesh, President of the Illuminating Engineering Society; E. W. Lloyd, Vice President of the Commonwealth Edison Co.; M. H. Aylesworth, Managing Director of the National Electric Light Association, and E. H. Sniffin, of the Westinghouse Electric and Mfg. Co. Round trip tickets may be secured at one and one-half fare, from any points in the Central Passenger Association by means of identification certificates. Special entertainment will be arranged for the ladies, consisting of horse-back rides, golf, tennis, cards and dancing, and they are cordially invited to attend. Hotel reservations should be made direct with the French Lick Springs Hotel Co., French Lick, Indiana, specifying that they are in connection with the National Electric Light Association Convention.

WARREN WEBSTER & CO. announces the opening of a branch office in Des Moines, Iowa, under the management of Harry E. Drain. This branch will serve the requirements of customers in Iowa, operating under the Webster Chicago Branch Office. The company also announces the appointment of Max Paul Miller as District Manager of the Baltimore Branch Office. Mr. Miller has been associated with the company in the home office as Sales Engineer for many years.

FREDERICK IRON & STEEL CO., and Frederick Engineering Co., Frederick, Md., announce that W. A. Riddell, their president, is now in charge of the operations of the Hadfield-Penfield Co., Bucyrus, Ohio, succeeding E. H. Haslam, who has just resigned from the presidency of the latter company.

HARRY E. DEXTER, formerly acting manager of the commercial division of the Servel Corp., has been appointed by Dr. Julian Klein, Director of the Bureau of Foreign and Domestic Commerce, as chief of the Electrical Equipment Division of the Department of Commerce.

DEAN BROS. CO., Indianapolis, Ind., announces that in order to give quick service and attention to the handling of its pumps and those of the Dean Hill Pump Co., in Philadelphia and vicinity, it has established a sales and service office in the Real Estate Trust Building, Philadelphia.

WM. B. TULLACH, for six years master mechanic of the Evanston plant of the Youngstown Sheet & Tube Co., has resigned to accept an appointment as Chief Elevator & Boiler Inspector of the City of Evanston, Ill.

THE INLAND POWER and Light Co. of New York City is constructing a 10,000-kw. hydro-electric generating plant on the Clearwater River just east of the city limits of Lewiston, Idaho. When completed the plant will be operated by Pacific Power and Light Co. of Portland, Oregon., and will serve the municipal and saw mill requirements in its district.

Water will be impounded by a concrete dam approximately 1200 ft. long, built across the Clearwater River. About 7000 ft. of earth dike will be constructed from the dam westerly and southerly to the power house to be located about 3500 ft. west of the dam. First installment calls for one 5000-kw. Allis-Chalmers unit, and provision will be made for a similar unit when needed. The tailrace will be 4500 ft. long, and will necessitate the removal of approximately 500,000 yd. of material.

Above the dam, about 300 acres will be flooded to form a log storage and forebay facilities for the Clearwater Timber Co., which is now erecting a sawmill of

200,000,000 ft. capacity a year. This mill will handle only white pine from the Clearwater River region.

Concrete work will be constructed by Fegles Construction Co. of Minneapolis; Winston Brothers Co. of Minneapolis, are the general contractors in charge of power plant construction and installation. The plant of the Clearwater Timber Co. was designed by F. W. Horstkotte, of Portland, Oregon.

American Brown Boveri Electric Corp. announces the opening of a district sales office in Philadelphia at 922 Witherspoon Bldg., in charge of Louis T. Peck.

Standard Turbine Corp., Scio, New York, announces the appointment of C. R. Gould as its general manager. Mr. Gould has been recently identified with Kerr Turbine Co. as purchasing agent, treasurer and secretary.

At the dinner recently held to celebrate the 25th year of activity of the Stephens-Adamson Mfg. Co. at Aurora, Ill., in making conveying machinery, the table was equipped with a complete belt conveyor, extending down the center for 67 ft. Courses were served on the belt, which was 18 in. wide, ran on ball bearing carriers, was reversible and operated so smoothly that a glass of water could be served without spilling. It was a demonstration of effective service without waiters and holds a suggestion for a new application of power and conveying equipment to the convenience of modern life.

Prentice Packing & Cold Storage Co., Yakima, Wash., has just completed a reinforced concrete fruit packing storage and shipping plant 118 by 220 ft. in size and two stories high with a basement. This plant contains a Vilter ice machine 9½ by 9½ in., belt driven from a 60-hp. Fairbanks-Morse Diesel engine. Power is generated by a 30-kw. Fairbanks-Morse, 220-v. Diesel-driven generator. All expansion and suction valves are centrally located in the engine room and connected to a defrosting header. J. Linderman, refrigerating engineer, Yakima, superintended the installation. Operation is in charge of K. F. Allen, chief engineer.

Examination is announced for Assistant to Chief Plant Engineer for the Quartermasters Corps, Fort Mills, Philippine Islands, at $2700 to $3000 a year and for similar positions in other locations. The present position is in a large central station, having steam, refrigeration and electrical plant. Competitors will be rated on education, experience and fitness, and applications must be on file at Washington, D. C., by Sept. 28. Blanks may be obtained from the U. S. Civil Service Commission at Washington or the local secretary of the board of examiners at the post office or custom house in any city.

For its new central station at Genoa, Italy, Societa Generale Italiana Edison di Electricita has just placed a contract for six Taylor stokers with the American Engineering Co. of Philadelphia. This station which is to be followed by two similar stations in Milan and Reggio, will go into operation late in the autumn of 1927.

These three stations will be the largest in Italy and their initial capacities of 100,000 kw. each will rank them among the most important stations of Europe. They will be tied in with existing steam and hydro-electric stations by a network of transmission lines covering the highly developed industrial section in northern Italy.

American or British coal, and occasionally lignite, will be burned, depending upon which fuel can be most advantageously obtained at the time. The stokers were chosen with this consideration in mind and are provided with a system of distributing rams that makes it possible to adjust the feed of the coal along the stoker grate surface to suit the burning characteristics of various kinds of coal. They will be the largest stokers in Europe and will be of the same general design as the Taylor stokers at the Kearny station of the Public Service Production Co. of New Jersey. The stokers are especially designed to permit the use of combustion air preheated to 225 deg. F. in accordance with the practice in the more recent Taylor-stokered central stations in the United States.

Washington Fruit & Produce Co., Yakima, has just installed one 100-t. Vilter refrigerating machine, belted to a 150-hp. Fairbanks-Morse motor, thus giving the plant a total refrigerating capacity of 225 t. Installation was supervised by G. W. Casebolt of the Vilter Mfg. Co. The plant is operated by G. Holm, chief engineer.

West Penn Power Co., Pittsburgh, is pushing construction on a large power sub-station at Butler, Pa., and proposes to have the plant ready for service at an early date. A power line is being built from the central generating plant at Springdale on the Allegheny River. A large part of the output will be used at the Butler plant of the Columbia Steel Co.

International Paper Co. has just awarded to the Dominion Construction Co., of Toronto, the contract for the construction of its hydro-electric development to be carried out by its subsidiary, the St. John River Power Co., at Grand Falls on the St. John River, New Brunswick. The contract includes construction of the main dam, tunnel and power house to cost about $1,500,000 and work is expected to begin within a few days.

Rapid strides are being made in the construction of the 135,000-hp. hydro-electric development at the falls of the Ohio River at Louisville, Ky., which the Byllesby Engineering & Management Corp. is building for the Louisville Gas & Electric Co. Most of the preliminary coffer-dam work has been finished and a start has been made on the navigation dam. Foundation work on the power plant also is in the preliminary stages. It is expected that the power plant will be in operation in the fall of 1928.

To impound and save water for developing power during the times of peak loads, the Connecticut Light & Power Co. is planning a unique development on the Housatonic river near the town of New Milford, Conn. It is stated that a concrete dam will be constructed and that two large centrifugal pumps will pump water into the lake created by this dam at the rate of 3750 gal. a second through a penstock 17 mi. long. The head thus created by this project will generate about 30,000 hp. during the time of peak load. Other dams will be constructed farther down the river. The centrifugal pumps will force water into the pond only during the period when the company's other stations have surplus power to spare, such as in the early morning hours before the factories have begun drawing power from the system.

Under an endowment fund created to provide four annual awards to employees or children of employees of

the Columbia System companies who are seeking college educations, four students will receive Columbia System Scholarships. The endowment fund was established in 1925 by Philip G. Gossler, president of the Columbia Gas & Electric Co., Cincinnati, O.

THE SOUTHERN CALIFORNIA EDISON CO., Los Angeles, Calif., has awarded a contract to the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., for two large horizontal waterwheel generators for installation at its Big Creek 2-A hydro-electric power station. The units will be the largest of this type ever constructed; each will have a capacity rating of 45,000 kv.a., and will be totally enclosed, complete with direct-connected exciters and auxiliary equipment. The generators will each weigh about 600,000 lb. and will be of a size 25 ft. wide, 23 ft. high, and about 14 ft. long.

ACCORDING TO a recent statement by Lloyd L. Root, California state mineralogist, efforts are being made to revive hydraulic mining in California so that the $600,000,000 in gold, estimated to be in the gravel of Sierra, Plumas, Nevada, Placer and other counties can be recovered in such a way as to protect the farmers in the valleys from the debris which was formerly swept down by the hydraulic methods used. In order to do this, a series of large dams, costing approximately $50,000,000, is to be built on the Yuba, the Bear and the American Rivers, which will allow the debris from the hydraulic mining operations to fill only about 10 per cent of the space. These dams will also aid in flood control, irrigation and hydro-electric power projects. The hydraulic mining industry has been inactive since the passage of the Sawyer injunction but it is now proposed to secure the $50,000,000 necessary from the United States Government as a loan and to revive the famous California placer gold deposits.

FOR THE ENGINEER who has power plant specifications to write or check over, the 1925-26 Report on Specifications by the Prime Movers Committee of the National Electric Light Association will prove a most dependable and detailed guide. In fact, we know of no other published material on the subject that takes up the definite items involved in a specification and shows what data should be given and how it may be arranged. This report does all these things and aims to assist the specification writer in producing specifications which will clearly describe the equipment wanted and the performance expected of it under given conditions.

It is recognized that inflexible standards cannot be set up to apply in all cases. No attempt has been made, therefore, to place any limits on the characteristics of the equipment. It is assumed that the specification writer is sufficiently familiar with the equipment wanted to determine the necessary details and place the limits to meet his own particular conditions.

The Commmittee's first report (Pub. 25-64, July, 1925) covered a general outline and standard forms for specifications for boilers and boiler feed pumps. The present report covers a general outline of specifications and proposed standard forms for specifications for surface condensers, stokers, forced draft fans and superheaters.

Copies of the report are sold to N.E.L.A. members at 15 cents each and to non-members at 25 cents each; they may be obtained from the secretary at 29 West 39th St., New York City.

Catalog Notes

THE MASTER BUILDERS CO., Cleveland, O., has just published a manual of concrete hardners, containing detailed architectural specifications for all approved types of hardners, both integral and surface treatment, and both colored and uncolored. The book is loose-leaf in form and of standard letter size with pages indexed for ready reference. This company has also issued a similar bulletin discussing specifications for water-proofing and damp-proofing, and both booklets are supplied free upon request to the company.

THE HILL CLUTCH MACHINE & FOUNDRY CO., Cleveland, O., has just issued catalog No. 26, containing information on its power transmission equipment together with other engineering data. The catalog gives full details concerning items such as flexible couplings, oil film bearings, clutch pulleys and cut-off couplings, automatic belt tighteners, American and English systems of rope drives, agitator designs, parts and gearings and similar equipment. The catalog is divided into three sections and is substantially bound.

USE OF THE CEMENT-GUN manufactured by the Cement Gun Co., Inc., Allentown, Pa., in rebuilding and maintaining furnace linings is discussed and illustrated in a recent booklet issued by the company. The booklet also describes and illustrates the new "Baby" Cement Gun, a portable machine, weighing 200 lb., requiring 60 cu. ft. of actual free air per min., at a pressure of from 35 to 50 lb. The new unit is designed particularly for use in small power plants.

HELICAL GEARS are described in a leaflet issued by the De Laval Steam Turbine Co., Trenton, N. J. Helical gears are used for ratios up to approximately 6 to 1, worm reduction gears being used for larger ratios for speeding up, as in driving centrifugal air compressors, centrifugal pumps, small pulverizers, etc., also for speeding down for slow speed machinery to avoid the use of special motors.

MOVEMENTS TOWARD standardization of industrial products have been extended during the past year and savings from standardization work are constantly growing in magnitude, according to the year book of the American Engineering Standards Committee, just issued. More than 200 definite standardization projects are in process or completed under the auspices of the A. E. S. C. while 365 trade associations, technical socieities and government bureaus are cooperating in the work. Two of the important projects now under way are the standardization of drafting room practice, and the standardization of methods of graphically presenting facts. Progress has also been made on some 50 safety codes applicable to factories. Copies of the year book may be had upon application to the office of the American Engineering Standards Committee, 29 W. 39th St., New York.

CATALOG No. 270, sent out by the W. S. Rockwell Co., of 50 Church St., New York City, gives a discussion of the furnace conditions necessary for satisfactory use of oil in industrial heating furnaces. It emphasizes the importance of proper furnace design and arrangement, also the need for proper atomizing and gasi-

fication of the oils in order to get complete combustion. Varieties of burners for high and low pressure air and steam are illustrated and described, also combination gas and oil burners for using the fuels alternately as may be required. Automatic temperature control is discussed for maintaining uniform temperatures and a uniform atmosphere in the burning.

THE DUST RECOVERING & CONVEYING CO., Cleveland, O., has just issued bulletin No. 515, describing the application of the Dracco Pneumatic Conveying System to the unloading, conveying and reclaiming of alum in the Fridley Municipal Water Filtration plant at Minneapolis, Minn.

MILWAUKEE ELECTRIC CRANE and Manufacturing Corp., of Milwaukee, Wis., just issued its catalog No. 100, which is an exceedingly interesting and attractive book designed to give the crane buyer some useful information on electric traveling cranes and hoists, in addition to telling the particulars about Milwaukee equipment.

IN AN ATTRACTIVELY illustrated, 48-page booklet, just issued by the Keystone Lubricating Co., Philadelphia, Pa., is described the Keystone Safety Lubricating system, designed to lubricate all the bearings of a given unit of machinery from one central point. Various types of installations are discussed and illustrated, together with the accessories that have been designed to reduce the amount of attention necessary for lubricating the unit.

YEOMANS BROS. CO., Chicago, Ill., in Bulletin S-130, just issued, describes the type HVS horizontal centrifugal pump with enclosed impeller for general service. These pumps are of the vertically split type and can be supplied either single or multi-stage and in capacities from 10 to 550 g.p.m. for various heads and usually arranged for motor drive. The Yeomans type HVO, an open impeller centrifugal pump in single and two-stage types, is described in Bulletin S-120.

Leaflet No. B-331 describes the Yeomans Automatic Junior Drainage Pump. This is designed to pump clear water from basements, boiler rooms and other areas below sewer level. It is built in four sizes from 35 to 50 g.p.m. is furnished with motors for 115 and 230-v. d.c. or 60-cycle, single or three-phase a.c. operation. A float operated automatic switch controls the starting and stopping of the motor according to the rise and fall of the water.

THE WESTINGHOUSE ELEC. & MFG. CO., East Pittsburgh, Pa., has recently issued publication SP 1734, devoted to the subject of regulators for generator voltage control. It contains a number of articles on the subject of regulation equipment which have never before been published. The theory and principles of various types of regulators are fully described by means of photographs and diagrams.

BITULUMINUM is the title of a booket, containing questions and answers on aluminum paints and metal primers, sent out by Hill Hubbell & Co. of San Francisco, Calif. Copies can be had by writing the company.

PRINCIPLES AND METHODS of heat saving, a joint report of the National Association of Building Owners and Managers and the National District Heating Association, has just been received. This bulletin discusses the principles and methods of heat utilization, ventilation, building losses, short-hour heating and gives extremely interesting data on steam consumption and savings made in heating buildings. It will prove of great value to all those who have such buildings under their control.

WEBSTER SINGLE and double roll coal crushers in both plain and bypass types are described and illustrated in a new bulletin issued by the Webster Mfg. Co., Chicago, Ill.

STANDARD BUILDING CLEARANCES for Whiting Overhead Electric Traveling Cranes are tabulated in bulletin No. 176 issued by Whiting Corp., Harvey, Ill.

THE MANTLE patent unit recuperator for recovering waste heat from flue gas for air preheating is described in the bulletin just issued by Mantle Engineering Co., Pittsburgh, Pa.

TAYLOR SPIRAL riveted pipe made of copper bearing steel is described in a folder issued by American Spiral Pipe Works, Chicago, Ill., folder showing applications of the pipe for water supply, hydraulic mining, power plant piping and mill work.

CHICO REFRACTORY PRODUCTS, such as flat suspended arches, wall tie blocks, boiler door arches, Brikset, a high temperature cement, Thermopaste and similar products, are described and illustrated in Bulletin 1, series C, just issued by Chicago Fire Brick Co., Chicago, Ill.

WARREN STEAM PUMP CO., Warren, Mass., has just issued bulletin No. 203, describing and illustrating the Warren multi-stage, balanced type, centrifugal pump. One characteristic of this pump is that the high pressure stuffing box has to be packed only against the pressure of the first stage.

GENERAL REFRACTORIES CO., Philadelphia, Pa., in a new four-page leaflet, describes Grefco, a new high temperature cement. The basic component of Grefco is chromite, it has a reasonably quick and strong cold set and its fusion temperature is over 3500 deg. F. Sample will be sent on request to the company.

THE STRONG, CARLISLE & HAMMOND CO., Cleveland, O., has just issued an attractive, well-illustrated, 56-page bulletin, Catalog 30-A, describing in detail its steam traps equipped with Anum-Metl seat and disc, its separators, regulators, non-return and throttle valves, engine stops and other steam specialties.

THE HANNA bull riveter, designed to drive a rivet with one stroke, is discussed in detail in a new bulletin just issued by Hanna Engineering Works, Chicago, Ill. The principle on which the riveter operates is illustrated and many interesting photographs show the applications of it to all types of work.

ROLLER-SMITH CO. has issued bulletin No. 550 describing its new type S-R line of relays, superseding its old Imperial type relays. The type S-R relays are designed with longer scales, greater accuracy and increased torque and can be furnished in the new 7½-in. round pattern case to match the type S-A and type S-D indicating instruments.

FURMANITE, a compound put up in cartridge form, to be used with Furmanite leak sealing equipment for sealing leaks in pipe, pipe lines, cylinders, tanks and other pressure containers without shutting off the pressure or interfering with plant operation, is described and illustrated in a bulletin just issued by The Furmanite Corp., Newport News, Va.